NEW ENGLAND WATER WORKS ASSOCIATION.

ORGANIZED 1882.

Vol. XX. December, 1906. No. 4.

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PUMPING WITHOUT AN AIR CHAMBER.

BY GEORGE A. STACY, SUPERINTENDENT WATER WORKS, MARLBORO, MASS.

[*Presented September 13, 1906.*]

Some few years ago I was standing in our pumping station near a compound duplex condensing pumping engine of about three million capacity, with a friend of mine, who had had large experience in the designing and the management of pumping engines. Noticing the generous proportions of the air chamber on this particular pump, he made the remark that he believed that under the conditions under which that engine was working, the air chamber was not necessary, and was, in fact, practically worthless as regards any efficiency or smoothness of working of the pump. I paid no particular attention to it at the time, although it struck me as possible that it might be so, as we had begun at that time to do away with air chambers on boiler feed pumps, the boiler itself acting as the air chamber. In this case the pump was working through 1 500 feet of force main directly up to the reservoir, and I did not know but it was possible that we could remove the air chamber and never notice the difference.

I had no occasion to try the experiment, however, until a few months ago, when word came from the pumping station that when they shut down and released the water from the pumps, through what we call the starting valve, the pressure was not reduced, and the water kept coming as evidence that there was something the matter with the check in the force main. On investigation, I found that one of the valves had broken. It was a three-ported

valve, built about twenty-three years ago, and the closing mechanism of the valves or ports was made of leather, — a type which you are probably all familiar with. To-day check valves of small size are sometimes made that same way. That is, the leather constitutes the covering for the valve-seat, being riveted to plates of iron to give stiffness, the joint or hinge being made by the leather between the plates; one which covers the opening and the other which is bolted to the body of the valve. The continual working of the valve for years weakening the leather, the one covering the middle port broke and dropped down. Not having leather I considered suitable to renew it with, we put the bonnet on the valve until such time as we could get it from the manufacturer of the valve, and went ahead with the pump without the check. Of course, the first day we had the air chamber charged as much as usual. In starting up the next morning, I told the engineer to go ahead with the pump all charged and the pressure on it, and if it didn't start up all right, to send for me. I will say, by the way, that I am responsible for the pumping engines on our works and all the mechanical details, and when anything goes wrong, I am supposed to be the doctor. The pump started all right with a full reservoir head on it, but in the afternoon of the second day I was called up and told that the pump wasn't working first rate. I went up to the pumping station and I found that at the end of the stroke there was a considerable jar. The pump had always worked very smoothly; as we say, it turned the corners quietly, but now you could see a marked change in the running. It was nothing very injurious, but it was rather annoying to an engineer; the noise was like discord to a musician. You would notice, as soon as you came within hearing of the pump, that there was something a little out of the usual, but, as I say, it was nothing dangerous, only it was unpleasant.

The next morning I went up to see if everything was running properly. The pump had started up all right again, but there was still this hammer at the end of the stroke. Across the street from the pumping station are one or two houses, and the principal of one of our schools lives in one of them. His wife came over and said she wished I would come over to the house and see if I could tell her what was the matter with the water pipe. She said

she had had a plumber there the afternoon before, and about the time he went away the noise stopped, but that morning it was as bad as ever, so she was afraid perhaps he didn't understand his business and she wanted me to come over. I went over and the sound that I heard was what is familiar to most of us when the ball cock in a tank gets to vibrating, as it will sometimes under certain conditions, and we get that chug, chug, chug, all over the house. Of course when that is kept up incessantly all day long it would be rather annoying to a lady, or even to a man with strong nerves.

In my great wisdom I said at once, " Oh, I will fix that for you very quickly." I went to the water-closet tank, but I found everything quiet there, no vibration whatever. I asked where the tank for the hot water was, and she told me it was up in the attic, so we got a ladder and I crawled up through the scuttle-hole and brushed away the cobwebs and thought surely I would locate the trouble there, but to my surprise I could find nothing, and still this noise was going on. I thought less of my own wisdom at that time than I did when I started in. On coming down stairs I said, " How long has this been going on? " She replied, " It commenced yesterday, and I sent for the plumber and he came and worked all the afternoon and about the time he was going away the noise stopped, and he said he guessed it would be all right." I asked what time he went away, and she said about five o'clock. (That was about the time we stopped the pump.) I said, " Did it do this all night? " She said, " No; we didn't hear anything until this morning, when it commenced again. When we open the faucet we don't hear it." I went and opened the faucet and let a stream run about as big as my little finger, and the noise ceased; but when I closed the tap again, it would start up as before. I looked all around to see if I could find anything in the plumbing which would lead me to suspect a cause for that. Of course it flashed into my mind that the pulsations of our pump, in the absence of the air chamber, had given a new action to the water in the force main that it hadn't possessed before; but why it should set up a vibration in the service pipe to this house and not affect the service pipe to the next house, I didn't know. The service was metered, and the lady rather

objected to letting the water run, but I wanted a little time to consider the matter, and I said, "You let the water run a little, and I will make it all right on the meter question, and if it continues to make a noise, let the water run more, and I think we will solve the trouble to-morrow, and you won't have any more difficulty."

On my way to the engine house I was thinking how I was going to remedy the trouble. It was simple enough. All we had to do was to shut the main gate on the force main, using the starting valve to discharge the water and relieve the pressure from the pump, and then in the morning use the charging valves to charge the pump the same as usual, and after getting the pressure equalized, gradually open the valve on the main and go ahead. We then had air enough in the air chamber to run part of two days before the water absorbed the air.

It came to me that an air chamber even under those conditions was of some use, and that if a man was offering me an engine and saying he would guarantee it to work all right without an air chamber, I should take exception to it.

We never had any trouble after that, but it is a mystery in my mind yet what caused the water hammer in that particular service and not in the adjoining one, when the services were exactly alike, except that this one was perhaps sixty feet longer. This incident brought to my mind that while theory is an excellent thing, practical experience is oftentimes a good deal better. And while this was not destructive, and wouldn't have prevented the continued action of the pump, it did prove to me that an air chamber is worth all it costs in preventing such conditions, even if they were not half as severe as these were.

This may seem to be a very simple matter, but it impressed itself on my mind as one of the little things which go to make up our life and bother us a good deal sometimes, and if we have the problem already solved, we haven't got to go and hunt up the solution of it.

DISCUSSION.

A MEMBER. What kind of a pump was that?

MR. STACY. A Blake, just like all the tandem compound duplex condensing pumping engines, built about twenty-three years ago, of the old Worthington type.

MR. FRANK L. FULLER. I didn't exactly understand, Mr. Stacy, whether the air had been exhausted from the air chamber and after it was replaced there was no further trouble.

MR. STACY. I think very likely I didn't make myself plain on that point. On working the pump for the first day, you could see the water gradually creep up in the glass until the air was out of sight. Of course there was still some left, but the time came when the water absorbed all the air there was in the chamber, and we got a solid column of water, when, of course, the action of the air chamber was nothing, and at that time came the hard action on the pump and the water hammer in the house.

MR. FULLER. I have had that same trouble in my own house at Wellesley. I think my house must be nearly two miles from the pumping station, and what seems rather to conflict with Mr. Stacy's statement or theory is that we have had that trouble early in the morning before the pump would be started. I have generally, by opening a faucet at the end of a long pipe in the cellar, cured the trouble for a while, and then perhaps in a month or two we would have it again. I had rather concluded it was due to an accumulation of air in the pipes in the house, but I never was certain of that, because on opening the faucet I never noticed any especial discharge of air. That word "chug" expresses it exactly.

MR. STACY. In relation to that, Mr. President, there is another little experience I had in this way. A man I have been acquainted with for many years said to me, "George, you say that a meter can't run unless water goes through it?" "Well," I said, "water or air or something of that kind; it doesn't run of its own volition." He owned considerable real estate and had a number of meters, and he said, "I have a meter which runs when there isn't any water or anything else running through it." I said, "I can't see that meter any too soon." So he said, "I will drive you up soon." It was just on the outskirts of the city, perhaps half a mile from city hall. I said, "Don't forget, because that is the biggest wonder I know of." He says, "I know what you believe, but that is the fact, and I will show it to you." I said, "All right." So it went along, and every afternoon or every time I met him I said, "I want to see that

meter, but I don't want to go without you; I wouldn't miss seeing that meter for anything." He couldn't go then and it went for almost a week, when he met me and said, "George you needn't go." I said, "Why?" "Well," he says, "I have discovered what the trouble was. You said that no meter would run if we wa'n't drawing water, but we wa'n't drawing water at that place." The fact was that there was a long pipe which led out to the stable; the meter was in the basement of the hotel, and after shutting the faucet in the stable one day, he went and looked at his meter, and he saw the hand moving and it kept moving a little bit for some time. He rushed upstairs and couldn't find anybody drawing water, and he came back and the hand was still moving, and at last somebody opened and closed a faucet and it then stopped. He went and tried it again and it did the same thing, so he thought he had one of those wonderful things, a meter running with no water passing through it. The explanation was that way up in the attic, out of sight and hearing, except for what noise came through the piping system, there was a tank which supplied the hot-water system, with the usual ball cock attached, and the pipe running to the barn was long enough so that the water hammer on closing the faucet would counterbalance the ball on the lever; this water hammer and the reaction would cause the ball to vibrate, and a small amount of water would escape at each vibration, which was recorded by the meter. As he knew that nobody was drawing water in the house, he was thoroughly convinced he had found a meter which was actually going without any water passing through it. I only wish I had gone up there myself before he discovered it, and then I would have had the glory of solving the mystery.

THE NEW WATER SUPPLY OF THE CITY OF BROCKTON.

BY CHARLES R. FELTON, CITY ENGINEER, BROCKTON, MASS.

[*Read November 14, 1906.*]

Brockton is a city of about 50 000 inhabitants, chiefly engaged in the manufacture of shoes. Prior to 1903, water was taken from an artificial reservoir having an area of about ninety acres and a watershed of 3¼ square miles, and situated in the town of Avon. This water, while not unhealthful, was very highly colored, in some years averaging over .80, and in the lowest year never running below .48. The poor quality of the water, however, was not the primary cause for seeking a new supply.

The lowering of the reservoir to a depth of about seven feet below the rollway during the year 1899 led to the serious consideration of a new water supply, which had already received attention from Mr. F. Herbert Snow, formerly city engineer, and Mr. Horace Kingman, the superintendent of water works, who had made an excellent report. As the estimated quantity procurable from this source in a dry year was only 1 500 000 gallons per day, and our present average use of water is nearly 2 000 000 gallons, it is obvious that we moved none too quickly in the matter.

At this time the writer was asked to report all possible sources of supply to some expert to be selected by himself, and accordingly all available information was submitted to Mr. Desmond FitzGerald, of this society, and out of a large number of more or less desirable projects he reported most unqualifiedly in favor of Silver Lake. Even after this opinion was rendered, it was over a year before we were able to get the money appropriated to start on the work, the interim having been used in the discussion of the various schemes by the city government, where, curiously enough, a man's judgment on the question of water supply seemed to be quite

largely influenced by his party affiliations, — almost all the Republicans seeming to believe that Silver Lake was the best place to go, and the Democrats seeming equally unanimous in the opinion that while there might be several other reliable sources, Silver Lake was certainly out of the question. Having finally completed the work, however, every one, even its bitterest opponents, seems to be well pleased, and at least two of them now point proudly to their names on the bronze tablet at the pumping station commemorating their achievements as members of the City Council.

The selection of this source, however, on account of its limited watershed, was to a certain extent dependent on the amount of water which was deemed requisite for a future supply, and to justify my somewhat radical conclusions as to the proper amount of water for a city to use, I am giving the following table, showing the consumption of water in Brockton for the last fourteen years.

TABLE No. 1. WATER CONSUMPTION IN BROCKTON SINCE 1892.

Water mains in 1892 = 43.74 miles; in 1905 = 97.366 miles.

YEAR.	Population.	Total Consumption (million gals.).	Daily Consumption in gals. per capita.	Domestic use in gals. per capita.		Manufacturing (gals. per capita).	Street Sprinkling (gals. per capita).	Fountains (gals. per capita).	Unaccounted for (gals. per capita).*
				Metered.	Unmetered.				
1892	29 643	271.6	25.0						
1893	30 817	264.4	23.5						
1894	31 993	323.2	27.7	6.7	3.8				
1895	33 165	399.6	33.0	7.3	3.2	2.4	1.8	1.5	16.8
1896	34 544	403.8	32.0	9.2	3.3	3.2	2.2	1.4	12.7
1897	35 923	386.4	29.5	8.5	2.6	4.0	2.8	1.4	10.2
1898	37 302	369.3	27.1	10.3	2.8	2.7	2.2	1.3	7.8
1899	38 681	414.7	29.4	11.0	2.7	3.6	2.6	1.3	8.2
1900	40 063	429.0	29.3	10.9	2.5	4.0	2.5	1.3	8.1
1901	41 610	447.5	29.4	11.5	2.1	4.0	2.4	1.4	8.0
1902	43 159	506.8	32.2	12.8	1.4	4.2	2.2	1.6	10.0
1903	44 704	537.8	33.0	13.5	1.4	4.9	2.1	1.6	9.5
1904	46 248	591.3	35.0	13.4	1.5	4.8	2.1	1.5	11.6
1905	47 792	621.4	35.6	15.3	1.6	5.1	2.3	1.7†	9.6

* Includes all use for flushing water and sewer pipes, fires, and slip of pumps.
† 16 fountains.

The somewhat rapid increase during the past year or two has been partially accounted for, and the consumption is now below 35 gallons per capita.

The rate of consumption per capita which it was assumed in 1901 would be used was as follows:

1905	35 gallons.
1910	37 „
1915	39 „
1920	41 „
1925	43 „
1930	45 „

or, in other words, it was assumed that we should never use over 45 gallons per capita.

While it may seem to many of you who have large per capita consumptions improbable that we shall be able to keep our consumption down to these figures, I would say that for the last five years we have been able at the *beginning* of the year to predict our consumption usually within one per cent. of the actual use, and always within five per cent. This, however, may have been and probably was due as much to good luck as good judgment. A monthly estimate of the water consumption for the year is made by the city engineer, based on the probable increase in population and legitimate use, and handed to the superintendent of water works; and any increase over this prediction is never considered as a legitimate increase in the consumption unless borne out by the meters or other reasonable cause, and an explanation is immediately sought by the superintendent, who last year found a leak amounting to over 200 000 gallons per day by examining the pipes under the bridges.

It is noteworthy that we have only one period of high consumption, namely, in the summer, whereas unmetered supplies commonly have a high period during the winter months.

The ratio of each month to the average monthly consumption as now used in these estimates is as follows:

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
.95	.90	.91	.87	1.08	1.12	1.18	1.13	1.05	.98	.88	.95

In view of our past experience, we did not figure on the necessity for such a large consumption of water as is usually considered advisable, believing that the provision of such extended works as would be required to furnish these large amounts of water would be unwise and unwarranted in our particular case.

Silver Lake is distant from Brockton City Hall, in a straight line, 11½ miles, and is situated in four different towns, viz., Halifax, Pembroke, Plympton, and Kingston. It is 644 acres in area, and has a maximum depth of 72 feet; its elevation above city base is 50 feet, and its total watershed, including water surface, is 4.4 square miles. Its shores are sandy, and soundings show no mud of any consequence within 25 feet of the surface. The total population on the watershed in 1897 was 50, or 18 to the square mile.

The area and storage capacity of the lake for each successive five feet is as follows:

Depth.	Area.	Storage Capacity in Million Gallons.
At high water	644 acres.	5 371
5 feet below high water	538 „	4 370
10 „ „ „ „	414 „	3 563
15 „ „ „ „	372 „	2 902
20 „ „ „ „	337 „	2 312
25 „ „ „ „	286 „	1 801
30 „ „ „ „	238 „	1 353
40 „ „ „ „	120 „	606
50 „ „ „ „	64 „	198
60 „ „ „ „	21 „	37
70 „ „ „ „	2 „	

On account of its immense storage capacity, in proportion to its watershed, it is obvious that the date at which we reach the

amount of consumption which the watershed would supply continuously is not the date nor the consumption which the lake is capable of supplying, in figuring the date when more water will

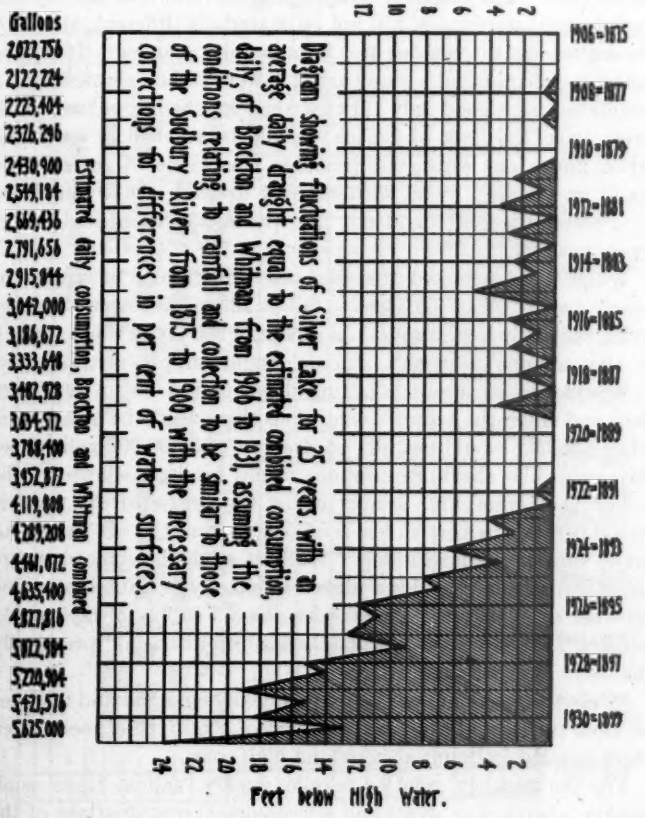

FIG. 1.

be required. Assuming that the next quarter of a century will have the same rainfall as the twenty-five years just passed, and basing our collection on the Sudbury River records, the above

diagram, Fig. 1, shows that the lake would furnish us until the combined consumption of Brockton and Whitman is over 5 000 000 gallons per day, without drawing the water down over 16 feet, or till about 1930. The length of this period warrants the assumption that the next similar one will not be materially different, although the sequence of dry seasons may be materially changed. It will be noted in this particular case that if it were to be assumed that a watershed were good only till that time at which it ceased to fill every year, the limit of capacity would be reached in six years, while under our estimated probable conditions of increase we could go eighteen years without ever drawing the water down to a point where it would not rise within *two feet* of high water every year.

While it is estimated that the lake will furnish a supply for nearly twenty years, and never fail to fill to within two feet, or until the daily consumption is about 4 200 000 gallons, which is the amount that this storage would supply continuously, it would necessitate the drawing down of the water nearly 20 feet, and under the assumed conditions there would be many years when the lake would not fill. A draught of 3 500 000 gallons per day under the above assumptions would result as shown by the following diagram, Fig. 2, and during the predicted dry spell it would perhaps be best to use some water from the old supply, to make sure of the lake filling. While it might be somewhat optimistic to figure that this would occur exactly as figured, provided no other supply were at hand, with our old supply always ready we feel that we can risk our assumptions being practically realized.

While the water of the lake is practically colorless and tasteless at most times, we have a short period of about three weeks when there is taste and odor although no high color.

For the past six months, regular weekly, and at times semi-weekly, chemical analyses and microscopical examinations of the Silver Lake water and of the several inlets to the lake have been made by Mr. George E. Bolling, our chemist and bacteriologist, and the following data are supplied by him.

The data afforded by the chemical analyses have indicated an absolute freedom from pollution from any animal sources.

The microscopical examinations have shown the presence of 33 genera at one time or other during the six months the water

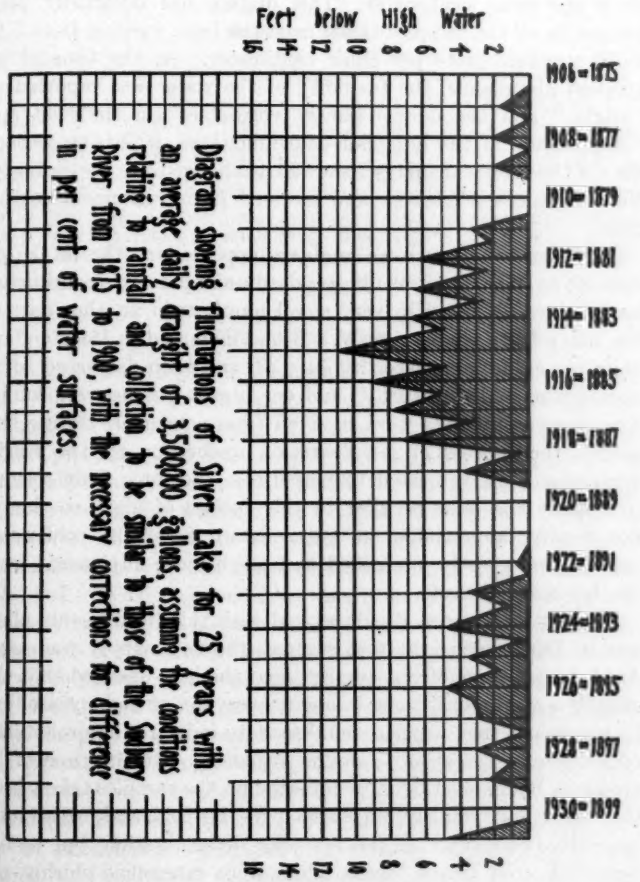
Feet below High Water
16 14 12 10 8 6 4 2
1906=1875
1908=1877
1910=1879
1912=1881
1914=1883
1916=1885
1918=1887
1920=1889
1922=1891
1924=1893
1926=1895
1928=1897
1930=1899
Diagram showing fluctuations of Silver Lake for 25 years with an average daily draught of 3,500000 gallons, assuming the conditions relating to rainfall and collection to be similar to those of the Sudbury River from 1875 to 1900, with the necessary corrections for difference in per cent of water surfaces.

FIG. 2.

has been examined. Of these 33 genera, 18 were plants and 15 animals. Melosira has been by far the most abundant, reaching the number of 2 070 standard units per cubic centimeter on March

20, 1906. From this number it decreased steadily until June, when the organism was present to the number of 30 to 40 standard units per cubic centimeter. This diatom has invariably been present in all the samples taken from the lake, varying from 5 to 2 070 standard units per cubic centimeter. At the time of its greatest abundance, the turbidity of the water was reported as "slight" and the odor "faintly vegetable" in the cold and "vegetable" in the hot odor determinations, while the various data of the chemical analyses showed no change from the ordinary. No complaints whatever were received from consumers at this time.

The organism known as anabena appeared at the intake on July 10, to the amount of 139 standard units per cubic centimeter, having been detected in very small numbers in another part of the lake a few days previously. It had increased to 159 standard units per cubic centimeter by July 23, and then decreased to 17 standard units by August 1, and on August 6 none were found. Numerous complaints were received from consumers during this period, the process of disintegration undergone by the fragile organisms while subjected to pressure in the force main serving to liberate the odor peculiar to this species of algæ, so that it was readily appreciable in water drawn from the cold-water faucets, and greatly intensified and much more unpleasant from the hot-water faucets.

The first experience Brockton had with this troublesome plant was in 1905, during the first summer the new supply was used. At that time some of the dwellers near the lake asserted that the growth occurred only once in about every six or eight years, but its recurrence this summer would seem to indicate the probability of an annual visitation from the organism. At the time of its greatest abundance the odors reported on the samples taken from the lake were "faintly vegetable" in the cold and "distinctly vegetable, corn-silk" in the hot odor determination, but as has been indicated before, these odors were intensified during the passage of the water through the pipe system to the consumer.

Crustacea have invariably been present in small numbers in all of the samples examined.

Following is a table showing the average analyses of the water of Silver Lake for the past three years:

PARTS IN 100 000.

YEAR.	Color.	RESIDUE ON EVAPORATION.			AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Fixed.	Free.	ALBUMINOID.				Nitrates.	Nitrites.		
						Total.	In Solution.	In Suspension.					
1903...	.09	2.96	1.10	1.86	.0016	.0138	.0113	.0025	.60	.0007	.0000	.25	0.4
1904...	.10	3.01	1.30	1.73	.0013	.0143	.0123	.0020	.62	.0010	.0000	.27	0.6
1905...	.10	3.18	1.26	1.92	.0020	.0120	.0099	.0021	.61	.0019	.0000	.22	0.6

THE FORCE MAIN.

The great length of the force main, and a difference of about $100 000 in the cost between the various trade sizes of iron pipe at about the probable limits of reason, viz., 20-inch, 24-inch, or 30-inch pipe, involved some very interesting work which space will hardly allow me to enter upon, as the various elements affecting the choice of a size would make a paper of reasonable length in themselves. Suffice it to say that for the 11½ miles of force main a 24-inch pipe was selected, rather than a 20-inch or a 30-inch, and fulfilled the conditions nearly enough to render it unnecessary to attempt a special size between the usual trade sizes.

As a rule in the streets the top of the pipe was laid about 4 feet below the surface; over private land about 3½ feet was usually sought, although we have some stretches of considerable length where the pipe is not covered over 18 inches. One course which we adopted, although not usually followed in pipe laying, was the filling of the joints inside of the pipe with Portland cement. My chief object in doing this was to reduce friction by adding to the interior smoothness. I figured that a reduction of 3 feet in the friction head would pay for the cost of doing the work. A careful friction test of the pipe since that time does not show conclusively that the friction was materially reduced, as it was almost exactly what is given in Weston's well-known tables for new pipe. This pipe was from one to three years old, however, at the time of the

test, but other friction tables give much lower friction rates than Weston's.

In the trench with the force main was laid a 6-wire lead cable for the telephone service and the Winslow recording apparatus. This cable was placed in a 1½-inch wrought-iron pipe, largely old pipe secured from the junk man.

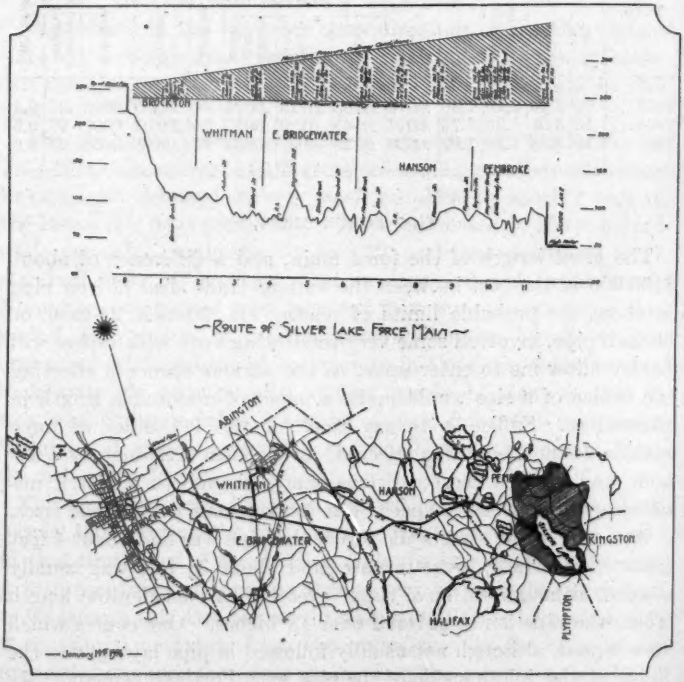

FIG. 3.
Scale of Plan, about 5 miles to an inch.

Air valves were placed on the main at all the summits, there being 22 on the line. We decided not to put in automatic air valves, but to send over the line occasionally and open them up. They consist simply of a regular 1¼-inch corporation and open-way valve, with a pipe running up nearly to the surface of

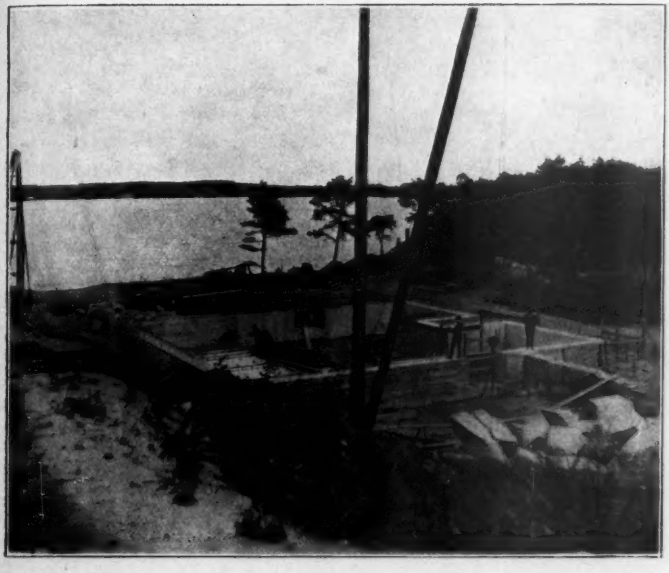

FIG. 1. FOUNDATION, SILVER LAKE PUMPING STATION.

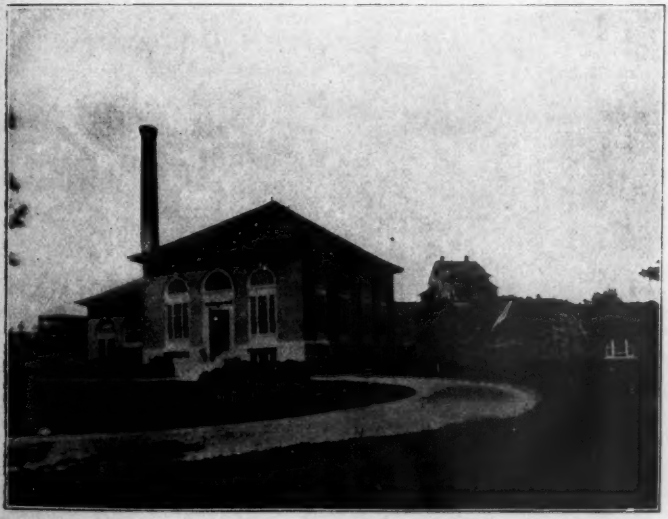

FIG. 2. SILVER LAKE PUMPING STATION.

the ground and a gate box over the pipe. A recent opening of all the valves after three months' operation showed no air in any summit except the one nearest the pump, where there was a very considerable amount, taking about one and one-half minutes to expel it before we got any water.

It may be interesting to state that the pump has been in operation over a year, under a pressure as high as 160 pounds, and that it has been necessary to remove only one cracked pipe; no joint leaks have yet been discovered, one joint leak having been recalked before the pump was started.

LEAKAGE IN THE FORCE MAIN.

There being but very little published information on the actual leakage in water pipes, it was decided to test this leakage in the force main.

As the pipe was laid from Brockton towards Silver Lake, it was possible to turn the water in as soon as the work was completed. A by-pass of 1-inch pipe with a $\frac{5}{8}$-inch disk meter was placed on the 24-inch main at a 24-inch gate, and the gate was closed here and at the end of the construction. The total distance was 22 476 feet, and the following observations were taken: From August 31 at 2.15 P.M. to September 1 at 7 A.M., about nine hours, the leakage was at the rate of 285 gallons per day; from September 1 at 7 A.M. to September 13 at 12 M., about twelve days, the leakage was at the rate of 277 gallons per day; the latter being at the rate of 65 gallons per day per mile of 24-inch pipe under an average pressure of 68 pounds. There had then been added 3 334 feet of pipe, making the total length 25 810 feet. The gate was opened and the following results were observed:

Average for first	$2\frac{1}{4}$	days,	the meter showed	100	gal.	per	day	per	mile.	
"	" next succeeding	$1\frac{3}{4}$	days,	82	"	"	"	"	"	
"	" "	"	4	"	58	"	"	"	"	"
"	" "	"	13	"	32	"	"	"	"	"
"	" "	"	50	"	20	"	"	"	"	"

The noticeable decrease may have been due to the stopping up of minute leaks, or possibly to the compression or expulsion of air in the summits.

After this it became inconvenient to make further tests; but desiring to get a test on the whole line, 61 000 feet in length, in combination with a friction test, after the pumps had been running about a year, all gates leading from the main were closed and observations were taken of the lowering of the water in the standpipe. This necessitated closing about 50 services, and about 50 other gates, comprising sizes 6-inch, 8-inch, 12-inch, 16-inch, and 24-inch, with one house service open. This indicated a leakage of 285 gallons per day per mile, under an average pressure of 71 pounds. While this does not show conclusively that the leakage in the force main was not less than 285 gallons per day per mile, it shows that it was not more than that.

A pipe wagon, designed by the superintendent, Mr. Kingman, is shown in the accompanying photograph. This apparatus is very quickly loaded and unloaded, and allows a pipe to be conveniently dropped at any point.

PUMPING ENGINE ECONOMY.

In the selection of the necessary duty to be specified for the pump, the following table was used, it being an adaptation of a table published by Mr. Coggeshall in a former JOURNAL,* the difference being that a unit system has been used so that it may be applied to any conditions, the rate of interest has been changed, and a life for the pump of twenty-five years has been assumed, which makes the figures materially different from those where interest alone is considered. From this table it is obvious that under our circumstances it was economical to pay a large sum for high duty, and in our particular case we offered a bonus of $350 per million for duties above 150 million, with a penalty of $500 for every million below 150.

TABLE No. 2. — ANNUAL COST OF COAL FOR PUMPING 1 000 000 GALLONS OF WATER DAILY TO A HEIGHT OF 100 FEET, WITH COAL AT $5.00 PER TON (2 000 LB.).

This table gives sums the interest of which at 3½ per cent. represents the saving effected by pumps of superior economy over an inferior one, assuming the life of the engine at twenty-five

* Vol. II, p. 240, June, 1897.

BARR PUMPING ENGINE IN SILVER LAKE PUMPING STATION.

PLATE II.

years, and establishing a sinking fund at 3½ per cent. interest to retire the first cost of pumps at that time. The table may be used in direct proportion for other heights, for other consumptions, or for other prices of coal.

Lower Duty.	Yearly Cost of Coal.	Higher Duty in Million Foot Pounds per 100 Pounds of Coal.									
		150	140	130	120	110	100	90	80	70	60
50	$1 522	16 920	16 300	15 600	14 800	13 830	12 680	11 270	9 517	7 250	4 233
60	1 268	12 680	12 070	11 380	10 570	9 600	8 450	7 030	5 283	3 020	
70	1 087	9 670	9 050	8 370	7 550	6 580	5 430	4 020	2 270		
80	951	7 400	6 780	6 100	5 280	4 320	3 170	1 750			
90	846	5 650	5 030	4 350	3 530	2 570	1 420				
100	761	4 230	3 620	2 930	2 120	1 150					
110	692	3 080	2 470	1 780	970						
120	634	2 120	1 500	820							
130	585	1 300	680								
140	544	620									
150	507										

Note. — Select the column headed by the higher duty. Then select the line beginning with the lower duty. The sum found at the intersection of the column and line is that which, under the above conditions, could be paid for the higher duty engine above the price of the lower duty engine.

PUMPING STATION BUILDING AND CHIMNEY.

The pumping station is well shown in the accompanying photographs. It is of red brick, the foundations of the pump room being of Portland cement concrete and of the boiler and coal room of granite. The pump, boiler, and chimney foundations are of concrete. The pump foundations extend four feet below the floor and are designed for a load of about one ton to the square foot, as are all the other foundations. This seems a very light load, but the material upon which we constructed was of a fine, wet, quicksandy nature, containing clay, and very unstable when unconfined. Space has been left for another pump, which would now be only for purposes of duplication, as it would be impossible to use the two in conjunction on account of the excessive friction head, although the size of the duplicate might be somewhat increased.

The chimney is of radial brick, 100 feet high, with an inside diameter of four feet at the top, there being no interior core above the common brick base 20 feet in height; this base is lined with radial brick of the same class as those in the chimney.

The boiler room contains two 264 horse-power water tube

boilers built by the Aultman-Taylor Company. They are of the well-known type made common by the Babcock & Wilcox Com-

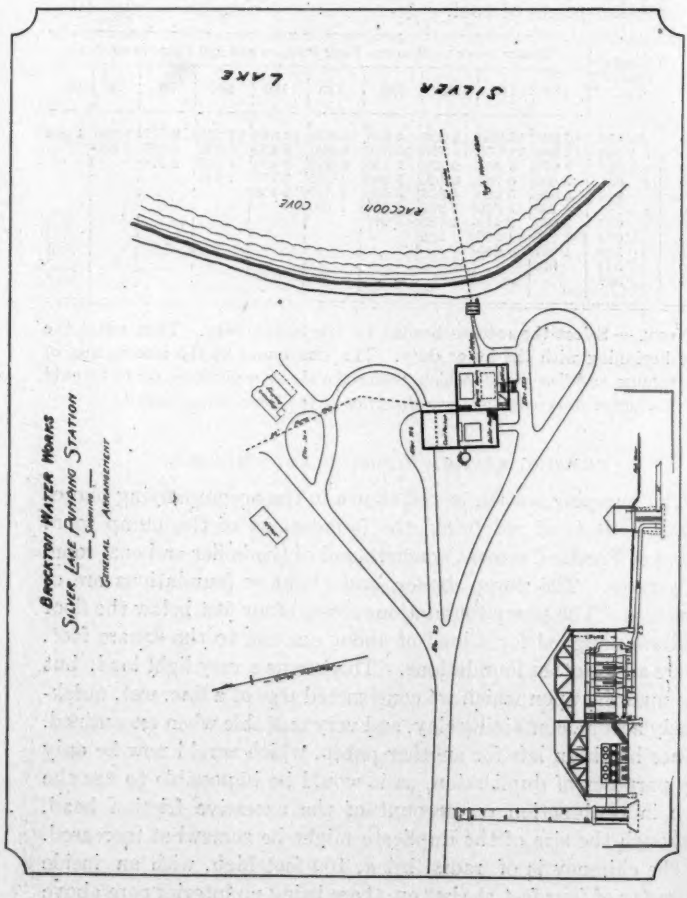

FIG. 4.
Scale of Plan, about 200 ft. to an inch. Scale of Cross Section about 100 ft. to an inch.

pany, and are insured to carry 160 pounds of steam. The coal room is 40 feet square and arranged to get the coal in at the top. A Green Economizer, to utilize the flue gases, is installed behind

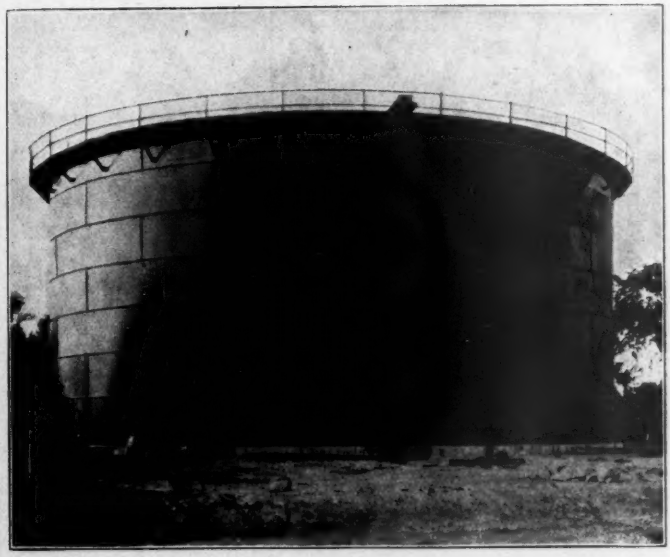

FIG. 1. NEW BROCKTON STANDPIPE.

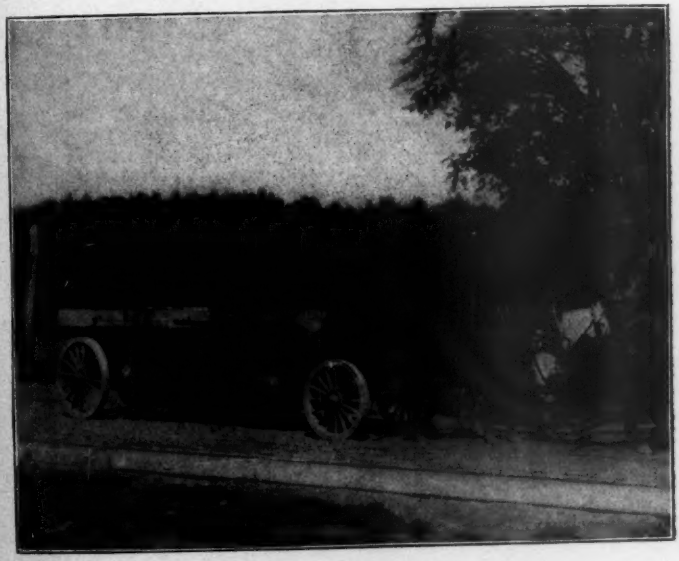

FIG. 2. PIPE WAGON.

Scale of Plan, about 200 ft. to an inch. Scale of Cross Section about 100 ft. to an inch.

the boilers, and heats the water about 100 degrees from about 90 degrees under ordinary conditions.

The pumps were furnished by the Barr Pump Company, and have a nominal capacity of 6 000 000 gallons per day. They are of the well-known vertical, triple expansion, crank and fly-wheel type, with cylinders 22, 36, and 59 inches in diameter, and three 19-inch water plungers, of 36-inch stroke. The valve area is 150 per cent. of the plunger area. The boiler feed pumps and air pump are attached to the low-pressure crosshead and have the same stroke. Condensing is done by a jet condenser. The steam cylinders are jacketed on the barrels, and the valves, of the Corliss type, are located in the heads; there are reheaters between the cylinders. The independent boiler feed, electric lighting generator, air compressor for cleaning boiler tubes, the repairing machinery and Green Economizer are all run by a small water motor discharging back to the lake.

The principal results of the duty test were as follows:

Principal Results.

Duration of trial, 10.30 A.M. to 8.30 P.M.	10 hours.
Total number of revolutions, by counter	20 118
Average revolutions per minute	33.53
Length of stroke, in feet	3 feet.
Average number of feet per minute piston travel	201.18

Temperatures.

Temperature of feed water	66°
Temperature of outer air for day*	71°
(Minimum, 56; maximum, 84.)	

Feed Water.

Total weight of water	46 753 pounds.
Leakage from boilers	375 pounds.
Total amount of water used by engines	46 378 pounds.

Pressures.

Steam pressure at throttle, by gage on engine	150.1 pounds.
(Corrected for water column.)	
Barometric pressure	14.61 pounds.
Absolute pressure	164.71 pounds.
Vacuum	25.8 inches.
Pressure by test gage on force main	119.5 pounds.
Difference between center of gage and water in pump well	20.9 feet.
Total water pressure (head)	128.6 pounds.

* At Brockton.

Duty, — Basis of 1 000 *Pounds of Steam (Plunger Displacement).*

$$850.5861 \frac{(128.6 \times 3 \times 20\,118 \times 1\,000)}{46\,378} = 142\,348\,630 \text{ foot-pounds.}$$

Capacity based on plunger displacement = 6 400 500 gallons per day.

A slip test of these pumps, using one of Mr. J. R. Freeman's calibrated 4-inch nozzles at a rate of about 5 200 000 gallons per day, indicated as lip of 2.8 per cent. (the fluctuations of the mercury column are well indicated by the following diagram, Fig. 5), and a later test made by pumping into the 75-foot diameter standpipe showed 2 per cent. slip, after allowing for leakage in the force main.

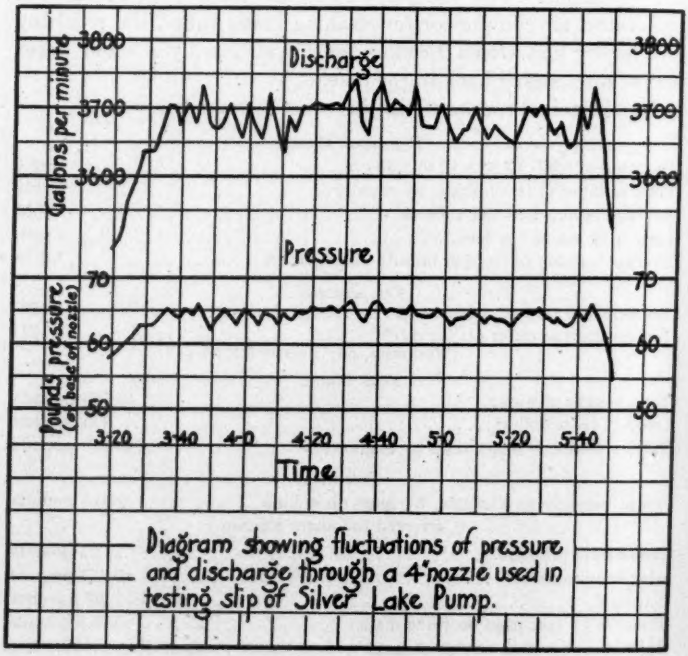

FIG. 5.

SCREEN HOUSE AND INTAKE.

The screen well is 12 feet in diameter, with a double set of ¼-inch screens in grooves, and is situated about 50 feet from the pumping station. This well presented the most difficult problem of all our work. Three-inch tongued and grooved sheeting was driven before digging began, and extended about 12 feet below the bottom of the well; the material was a fine quicksand, and boiled up nearly as fast as it could be removed, settling the ground to a distance of 50 feet in some directions. The intake pipe is 30 inches in diameter, is laid level, and extends 225 feet into the lake. Owing to our experience with the pump well, we did not attempt to pump out the sheeting in the lake, but excavated between the sheeting with a small orange-peel bucket and stiff-leg derrick, floated the last section of the pipe — 156 feet in length — which was headed up with wooden heads, and sank the pipe by admitting water through rubber tubes, it being necessary to excavate and make one connection where the two sections joined. The end of the pipe rests on a concrete block about 3 feet above the bottom.

STANDPIPE AND PRESSURES.

The need of more storage capacity led to the construction of a new standpipe 75 feet in diameter and 35 feet high, with spiral stairway and balcony.

The top of the new standpipe is 3 feet 4 inches higher than the old one, and their combined capacity is about two and a half million gallons, or (which is more important, as we seldom allow them to go down over 15 feet and never more than 20 feet) about 55 000 gallons per foot.

The highest part of the city is at an elevation only about 12 feet below the top of the standpipes, but the high portion is very limited in population, and we have a static pressure of 50 pounds on over 70 per cent. of the hydrants, only 6 per cent. having less than 30 pounds, with about 4 per cent. over 70 pounds. A much higher pressure would, of course, be desirable.

The construction of the standpipe presents no unusual features. It has concrete foundations 3 feet thick, projecting 1 foot above

the surface of the ground. It is constructed of mild steel having a tensile strength of 54 000 to 62 000 pounds per square inch. The work was done with a pneumatic gap riveter. It is composed of seven courses of plates, with lap seams.

The following table gives the thickness of plates and pitch of rivets, all horizontal seams being single riveted; there is a $6 \times 6 \times \frac{11}{16}$-inch bottom angle on the *inside*, and a $3\frac{1}{2} \times 3\frac{1}{2}$ angle iron on the outside, 18 inches below the top. It is designed for unit strains of 13 500 pounds per square inch on the plates, and 9 000 pounds on the rivets, which are of steel. The bottom is $\frac{1}{2}$-inch thick.

	Thickness of Plate.	Vertical Riveting.		
		Rows.	Size.	Pitch.
Course 1.....	$\frac{11}{16}$″	triple	1″	3.71″
" 2.....	$\frac{5}{8}$″	"	$\frac{7}{8}$″	3.14″
" 3.....	$\frac{1}{2}$″	"	$\frac{3}{4}$″	2.83″
" 4.....	$\frac{7}{16}$″	double	$\frac{3}{4}$″	2.38″
" 5.....	$\frac{3}{8}$″	"	$\frac{5}{8}$″	2.29″
" 6.....	$\frac{5}{16}$″	single	$\frac{3}{4}$″	1.70″
" 7.....	$\frac{5}{16}$″	"	$\frac{5}{8}$″	1.70″

The standpipe is equipped with the Winslow recording apparatus, run by a float in an 8-inch pipe resting on but not secured to the bottom of the standpipe. The 8-inch pipe is 4 feet from the side of the standpipe, and is held in place by two brackets, one at the top of the standpipe and the other 12 feet from the bottom, the latter being below the intended low-water mark. The 8-inch pipe is perforated by a small hole about 2 feet above the bottom, and has about 3 feet of oil in the top of the pipe to prevent freezing. The movement of the float is perfectly steady and is apparently absolutely unaffected by surface fluctuations.

The cost of the standpipe erected, with stairway and balcony, including two coats of paint, was $10 550. The cost of the foundation, including excavation, was $3 209.49.

Four bids for a concrete-steel standpipe, based on the designs of the bidders, were submitted, and the bids ranged from $15 500 to $19 000. The lowest bid was received informally after the

others were opened; had it been before us at the opening, it is a question whether we should not have accepted it.

Owing to a strong local feeling, and not to any particular prejudices of the writer, the whole work, with the exception of the chimney and standpipe, including the erection of the buildings, was done practically entirely by city labor, the laborers being paid $2.25 per day of eight hours. This work was under the sole charge of Mr. Horace Kingman, the superintendent of the water works, and was ably carried through within the original estimates, in spite of the high cost of pipe.

DISCUSSION.

Mr. Desmond FitzGerald. I came here to-day, Mr. President, to listen rather than to speak, and it is needless to say that Mr. Felton's paper has proved interesting. In connection with the Brockton work I remember after making my report I received an invitation to spend an evening with the mayor, aldermen, and common council to answer any questions they might see fit to propound. You may imagine there were some questions asked which were somewhat embarrassing. Among them I remember this: "You recommend taking water from Silver Lake, which is 14 miles away. Now, sir, suppose there was a river of pure water directly under the city, flowing away in large quantities; would that be a sensible thing to do?" Well, what kind of an answer could a man make to that question? Naturally, it would be a very short one, that it would be a very foolish thing to do. I afterwards was informed that a certain learned professor in Harvard had stated his belief that one of those underground rivers we hear about so often was running under Brockton to the sea, and all they would have to do to get a supply of water there would be to drive a pipe down and tap it. [Laughter.] It is a fact that this supposed stream kept action on Silver Lake in abeyance for several months.

I think that Brockton is very fortunate in having such a fine source of supply as this lake. I remember the clearness of the water and the sandy beaches around the border. It seems to me that, so far as the quality of the water is concerned, there are few cities or towns as fortunate.

I have made a great many active enemies in my life, I am afraid, but among the most active I recall now is the old anabena. He has attacked the Boston water supply several times and so vigorously that a person could not take a bath in the water with any pleasure, and no one would venture to use it in brushing his teeth. We didn't know much about him at that time, but we came very closely in contact with him and found good reason for shunning his acquaintance. I am, therefore, very much pleased to learn that the source of water supply I recommended to Brockton has only reached 128 per cubic centimeter. What would the people have thought if the number instead of being 128 had been 1 028 as I have frequently seen?

MR. MORRIS KNOWLES. I was especially interested in Mr. Felton's remarks about using second-hand pipe for laying the cable. We are laying considerable cable ourselves, and where we are not able to lay a tile conduit we have used tubing, understanding that it would be very difficult to draw a cable through pipe on account of their not being smooth at the joints. I should like to ask Mr. Felton how far apart the drawing-in manholes were, and if he experienced any trouble from injury caused in drawing-in.

MR. FELTON. No; we had no difficulty whatever, and never discovered that there was any mechanical injury to the cable. The drawing-in stations were about 500 feet apart. We thought of the possibility of injury and considered seriously whether we shouldn't lay the cable without any covering, except in the streets. There is quite a large portion of the line over private land and through woods, and the pipe is only to prevent mechanical injury. When we first got the thing finished, as we thought, we couldn't make it work for a while. We suspected it was the fault of the man who made the joints, so we had some one go over the line and inspect them, and he found some that were weak; it was claimed water had got into them, and since they have been made right it has never failed to work in good shape. The recording apparatus has worked satisfactorily, although we have a little trouble with the float on account of the lengthening of the string. It is supposed to record every 3 inches, and it hasn't been more than 9 inches out at any time, but it has been as much as that. We can't depend upon it within 6 inches, on account of the float slipping on the wheel or possibly a little slipping of the string.

MR. FITZGERALD. I should like to ask what the nozzle pressure of that 4-inch stream at the lake was.

MR. FELTON. The nozzle pressure was about 62 pounds and the pressure at the pumps was about 140, the difference being lost in friction.

MR. FITZGERALD. What was the horizontal distance of the stream above the lake?

MR. FELTON. I am sorry to say we didn't get a good measurement of that, and I can only judge by the photograph. I should say the bulk of the stream was very nearly 200 feet, but it broke up a good deal, as you noticed in the slide, giving a very beautiful effect, with rainbows, etc.

A STUDY OF SOME VITAL STATISTICS.

BY L. M. HASTINGS, CITY ENGINEER, CAMBRIDGE, MASS.

[*Read November 14, 1906.*]

Nature has implanted in every sane person a desire to live, to prolong life, and pursue, as far as possible, health, and the capacity for enjoyment. The old story of Ponce de Leon seeking the fountains of eternal youth but illustrates the real desires of every human being, and typifies, in its story of search and struggle and final disappointment and defeat, the ceaseless effort of the human race to find some way by which the dread ravages of disease may be averted and the relentless hand of death stayed.

While the fabled " Fountain of Eternal Youth " has never been discovered, nor that magic potion which it was believed should forever preserve health and beauty been compounded, — at least in any such manner as the ancients thought possible, — nevertheless very much has been done in these later years not only to lengthen the average of human life, but to increase its capacity for productive work and enjoyment. Of the many causes which have tended to produce this result, perhaps the two most prominent are the marvelous progress made in medical discovery in the knowledge of the causation of many diseases, with an increased efficiency in its prevention or cure, and in sanitary science a far better understanding of the effect upon health of environment, — soil, climate, temperature, cleanliness, drainage, etc., — and the hygienic value of good food, water, and air.

In the field of medical discovery the most potent factor in producing the remarkable results obtained is the work of highly trained specialists and experimenters in natural and medical science. It would be difficult to overestimate the debt which the world owes to these scientific men who, by patient investigation and research, extending often through long years of poorly paid labor, have made discoveries and established theories

the application of which will be of incalculable benefit to mankind. This is all the more noteworthy because in many cases the amount of laborious experiment and research necessary to establish a single fact of importance is enormous, and the degree of scientific skill and intelligence required the highest.

Think, for instance, of the time and labor and patient investigation required to discover and demonstrate — what is now generally accepted as correct — the general theory of the germal origin of many diseases. How can the world repay Robert Koch, of Germany, who, perhaps more than any other one man, advanced the knowledge of bacteriology in its relation to disease, or Louis Pasteur, of France, who developed the method of cultures of these bacteria so that they could be readily examined or studied, and later discovered a remedy for that terrible malady, rabies, or hydrophobia, so that the mortality from the disease has been reduced from 60 to 80 per cent. to less than 1 per cent.?

Think of the work of Klebs and Löffler in Germany, in determining the bacteria of diphtheria, and of Behring in Germany and Roux in Paris in perfecting the antitoxin treatment for this terribly fatal disease, saving thousands of otherwise doomed victims.

As a result of the labors of these and a great many other men — physicians, chemists, bacteriologists, biologists, sanitary engineers — who have devoted themselves unselfishly to the cause of bettering humanity on its physical side, we have to-day advanced far on the road to a proper understanding of disease, its cause, prevention, and cure. We have also, in many ways, a far better and more rational standard of living than before; better food, befter houses, purer water, and better sanitary conditions in cities and crowded areas. One of the most striking demonstrations of the efficiency of this increased knowledge concerning disease of which we have been speaking is the decreased number and virulence of the outbreaks of contagious diseases and their greatly lessened mortality; smallpox, yellow fever, cholera, diphtheria, the plague, and similar diseases, have now no such terrors as formerly.

Another evidence of the practical value of this increased knowledge of sanitary and medical matters is a *lowered annual death*

rate. I believe that this result is pretty general throughout this country; it certainly appears in the statistics which I have examined, being most marked in the last decade, and especially in the *cities.* Now this lower annual death rate indicates a *longer average life* to the individual, with all its possibilities for enjoyment and for usefulness to the community. It also indicates a lessened *morbidity* or sick rate, with its burden of expense and lessened earnings.

Another fact worthy of notice is that this lowering of the death-rate has been largely among the *young,* or persons under five years of age, with the expectation of a long life before them. As will be shown, the greatest mortality occurs among the very young, and decreases as the age advances until about the fifteenth year, when the death-rate begins to rise again. If, therefore, the young can be carried over this period of greatest danger, their expectancy of life will be greatly increased.

It is to the credit of the new knowledge that this is exactly what has happened. The average annual death rate in Cambridge among children under five years of age for the thirty years from 1850 to 1879 was about 9.00 per 1 000 of all persons living, while for the ten years 1894 to 1903 it was only 6.08 per 1 000, a decrease of about 33 per cent.,— a very excellent showing.

The figures which I have prepared relate largely to Cambridge, but I think that in a general way the results are typical of those which obtain in cities in many parts of the country. Free use has also been made of the statistics given by Mr. Robert Moore in his excellent paper on " Vital Statistics of St. Louis since 1840," published in the *Journal of the Association of Engineering Societies,* November, 1904. They are used simply as an interesting comparison between localities remotely situated.

Climatic conditions, as indicated by temperature and rainfall, have an important effect on health and happiness, and so Fig. 1 is given, showing the precipitation and average temperature readings at New Bedford, Mass., 1813–1904. These are said to be the longest and most reliable set of meteorological observations taken in New England, being made entirely by Mr. Samuel Rodman and son for the time 1813 to 1904. A study of this plate would seem to show that while there has been some variation of

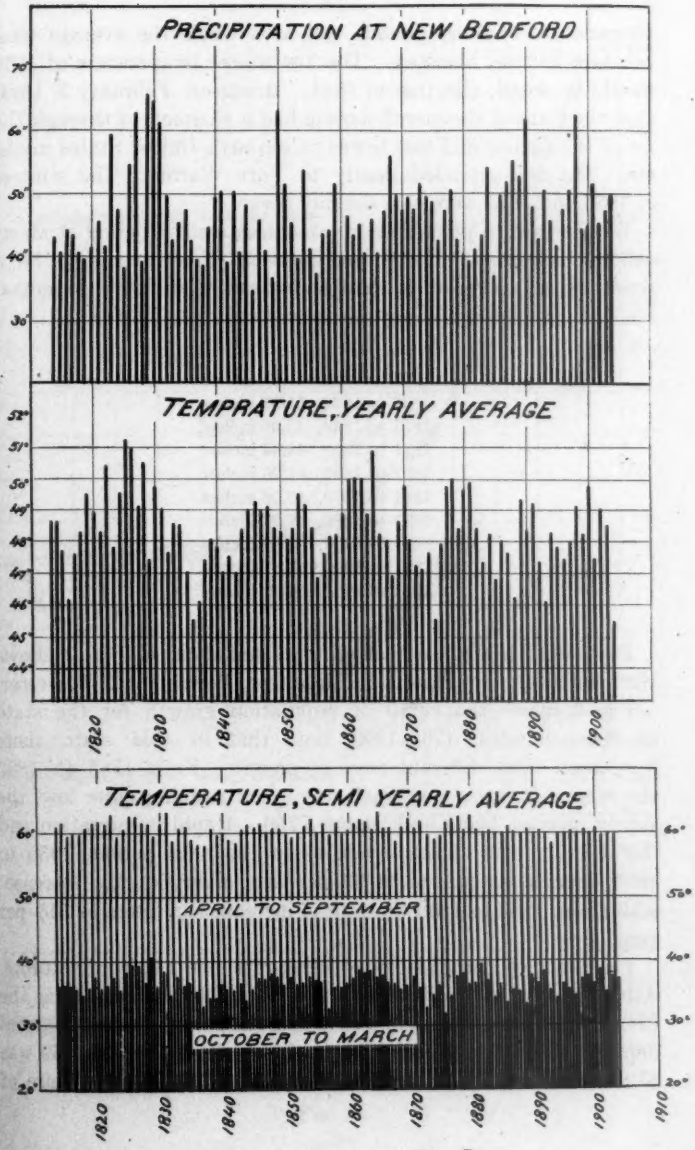

FIG. 1.—CLIMATIC CONDITIONS AT NEW BEDFORD.

temperature in short periods, yet as a whole the average temperature has not changed. The low winter temperature of 1836 should be noted; also that of 1844. It was on February 3, 1844, that the Cunard steamer *Britannia* had a channel cut through the ice of the harbor and was towed to sea with United States mails, etc. The ice extended nearly to Fort Warren. The winters of 1856 and 1875 were also notably severe.

With regard to precipitation, excepting a short period at about 1830 of abnormally large precipitation, there seems to be a tendency in this record to show an increase in the average annual amount, the average by ten-year periods being as follows:

1813 to 1820, 41.67 inches.
1821 to 1830, 51.95 inches.
1831 to 1840, 45.96 inches.
1841 to 1850, 44.94 inches.
1851 to 1860, 44.76 inches.
1861 to 1870, 46.26 inches.
1871 to 1880, 46.87 inches.
1881 to 1890, 48.69 inches.
1891 to 1900, 47.87 inches.
1901 to 1904, 48.69 inches.

Population is the basis of all vital statistics, so Fig. 2 shows the growth of population of Cambridge, Lowell, and Worcester.

Fig. 3 shows the curve of population growth for the state of Massachusetts, 1765–1900; note that in this state there have been three different rates of growth. From 1765 to 1830 the rate of increase was small, the curve running quite low, the yearly increase being only about 5 750. Rapid immigration and the development of manufactures in the next period, 1830 to 1885, brought the rate to 26 765 per year, a very marked increase; while from 1885 to 1900 the rate of increase has been 57 545 per year.

Fig. 4 shows the Cambridge birth-rate per 1 000 inhabitants. Attention should be given to the low rate indicated during the Civil War, 1861 to 1865, and also during the period of great financial depression, 1875 to 1879. The birth-rate from 1850 to 1859 was 37.83, while the rate from 1894 to 1903 was 29.54, a decrease of

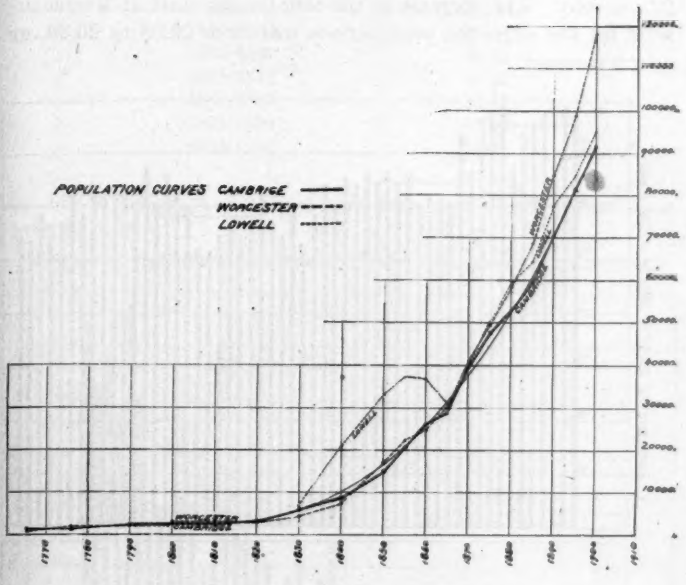
POPULATION CURVES CAMBRIGE
WORCESTER
LOWELL

FIG. 2.

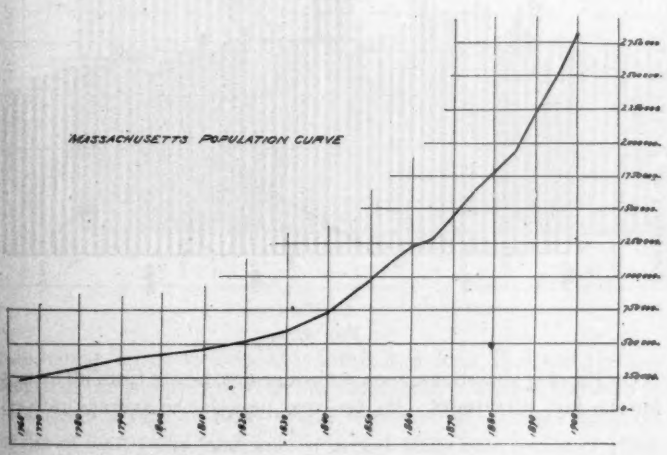
MASSACHUSETTS POPULATION CURVE

FIG. 3.

22 per cent. The decrease in the rate for the state of Massachusetts for the same ten-year periods was from 29.09 to 26.39, or over 9 per cent.

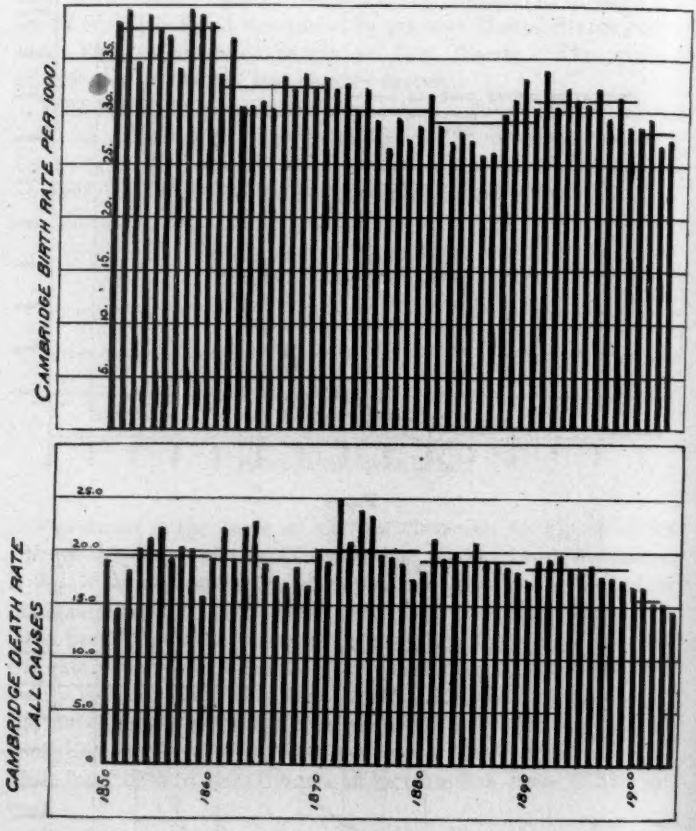

FIG. 4.

On Fig. 4 is also shown the Cambridge death-rate from all causes for the last fifty years. By ten-year periods the average rate is:

Period.	Death-Rate.
1850–1859	19.67
1860–1869	19.44
1870–1879	20.22
1880–1889	19.27
1890–1899	18.52
1895–1904	16.81

the last a reduction of 15 per cent. from that of the period from 1850 to 1859.

To get an approximate idea of what this decrease in the death-

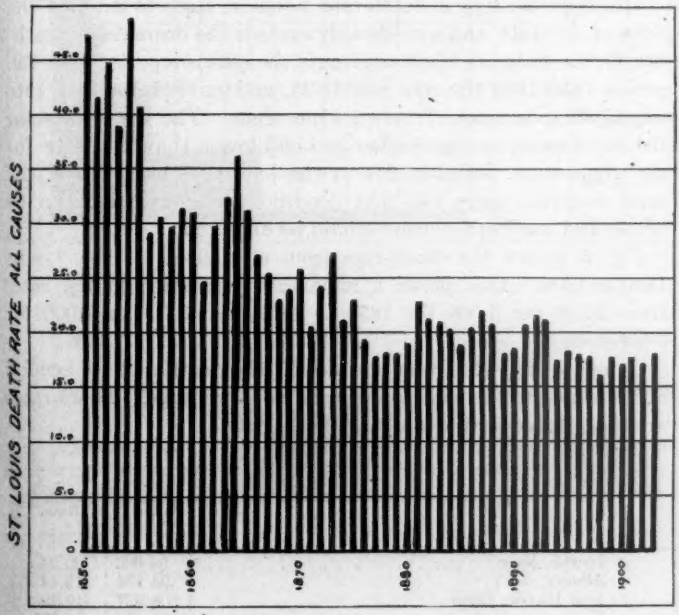

FIG. 5.

rate means, let us assume, as is sometimes done, that the average length of life is represented by the death-rate. Thus in the decade 1850–1859 a rate of 19.68 would represent an average duration of life of 50.3 years, and for the period 1895–1904 a rate of 16.81

would represent an average life of 59.5 years, a gain of 9.2 years. Who can estimate the value of this lengthened life? Or, look at it another way. If the death-rate of the first period had been maintained till the present time, the total number of deaths in 1904 would have been 1 980. As a matter of fact, however, the total number of deaths was only 1 444, or 536 less than would have occurred if the early rate had continued, being just so many lives *saved*. If, now, we give to each life its legal valuation of $5 000, we have $2 680 000 as the total value of the lives saved for the year 1904 alone in the city of Cambridge.

This large decrease in death-rate seems to apply to most of the cities of the state, and considerably exceeds the decrease in death-rate for the state as a whole as given in the census reports. For the period 1850–1859 the rate was 18.25, and for 1894–1903 the rate was 17.80, a decrease of only 2.4 per cent. The death-rate for the cities seems to start higher and end lower than the rate for the whole state, probably due to the balancing influence of the rural districts where the first conditions would be likely to be better and less improvement would be expected.

Fig. 5 shows the death-rate from all causes for St. Louis, 1850 to 1904. This shows a remarkable reduction in the rate, from 43.08 per 1 000 for 1850 to 1859, to 71.71 per 1 000 for 1894–1903.

Compare (for what they are worth) the death-rates of several cities of nearly the same population as Cambridge. These rates are the average for the ten years 1894–1903.

City.	Population.	Death-Rate.
Lowell, Mass.	94 969	20.24
Albany, N. Y.	94 151	19.44
New Haven, Conn.	108 027	17.29
Worcester, Mass.	118 421	16.87
Cambridge, Mass.	91 886	16.81
Hartford, Conn.	79 850	16.24
Syracuse, N. Y.	108 374	13.48
Dayton, Ohio	85 333	13.35
Grand Rapids, Mich.	87 565	12.04
St. Louis, Mo.	575 238	17.71

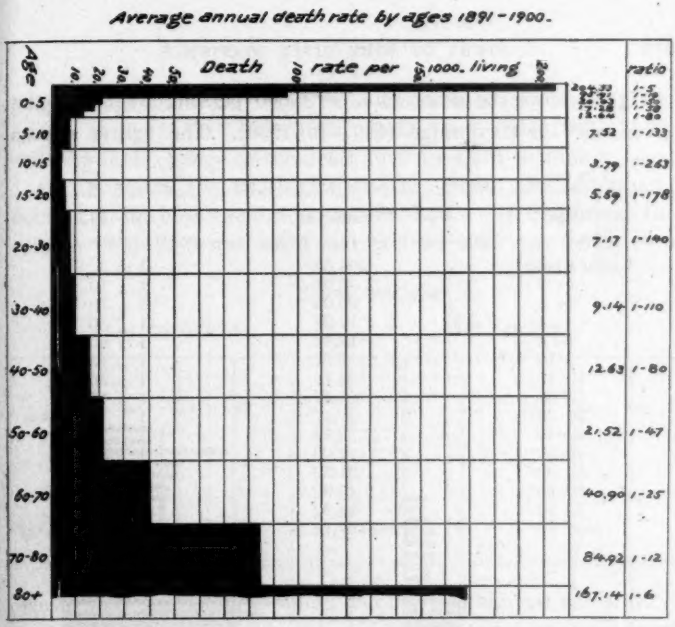
Average annual death rate by ages 1891-1900.
Age
Death rate per 1000. living
ratio
0-5
5-10
10-15
15-20
20-30
30-40
40-50
50-60
60-70
70-80
80+
7.52 1-133
3.79 1-263
5.89 1-178
7.17 1-140
9.14 1-110
12.63 1-80
21.52 1-47
40.90 1-25
84.92 1-12
167.14 1-6

FIG. 6.

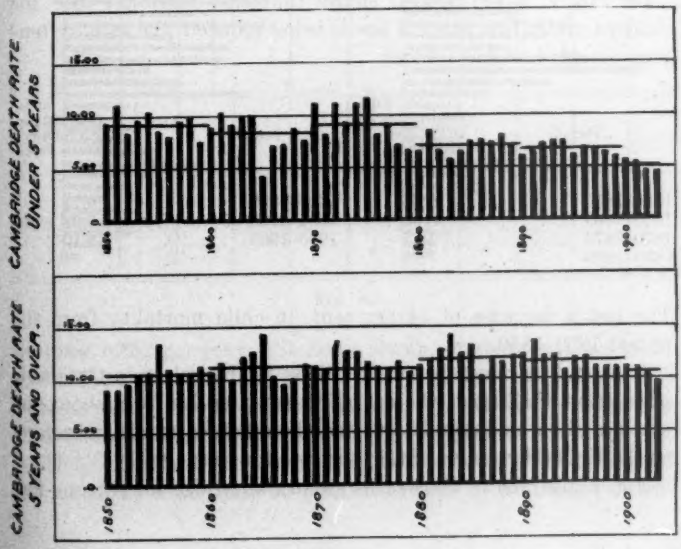
CAMBRIDGE DEATH RATE UNDER 5 YEARS
CAMBRIDGE DEATH RATE 5 YEARS AND OVER.
15.00
10.00
5.00
0
1850
1860
1870
1880
1890
1900

FIG. 7.

Fig. 6 shows the death-rate per 1 000 persons living of the given ages in Cambridge (1891 to 1900). The figures are as lows:

Age.	Death-Rate.	Mortality.
Under 1 year	204.53	1 in 5
1– 2	95.91	1 „ 10
2– 3	20.03	1 „ 50
3– 4	17.28	1 „ 50
4– 5	12.64	1 „ 80
5–10	7.52	1 „ 133
10–15	3.79	1 „ 263
15–20	5.59	1 „ 178
20–30	7.17	1 „ 140
30–40	9.14	1 „ 110
40–50	12.63	1 „ 80
50–60	21.52	1 „ 47
60–70	40.90	1 „ 25
70–80	84.92	1 „ 12
over 80	167.14	1 „ 6

Note the terrible mortality of children under one year of age, more than one in five dying.

On Fig. 7, however, it is shown that this mortality rate for children under five years of age is being reduced, the rate by ten-year periods being as follows:

Period.	Death-Rate of Children under Five.	Period.	Death-Rate of Children under Five.
1850–1859	9.26	1890–1899	6.77
1860–1869	8.33	1894–1903	6.08
1870–1879	9.25	1900–1903	5.10
1880–1889	7.25		

The last a decrease of 34 per cent. in child mortality from the period 1850–1859.

It should be remembered that these figures relate to the whole population of all ages, whereas children under five form about one tenth of the whole population, and these figures should, therefore, be multiplied by ten to obtain the rate for that age.

Fig. 7 also shows the death-rate in Cambridge for persons five

years of age and over. The rates are successively 10.69, 11.28, 11.05, 11.92, 11.76; 1900–1903, 10.62; and 1894–1903, 11.04, showing little change in the death-rate for adult persons.

Fig. 8 shows the death-rate due to croup and diphtheria combined for both Cambridge and St. Louis. In Cambridge the rate in 1880–1889 was 1.316 and in 1894–1903 was 0.626, or a

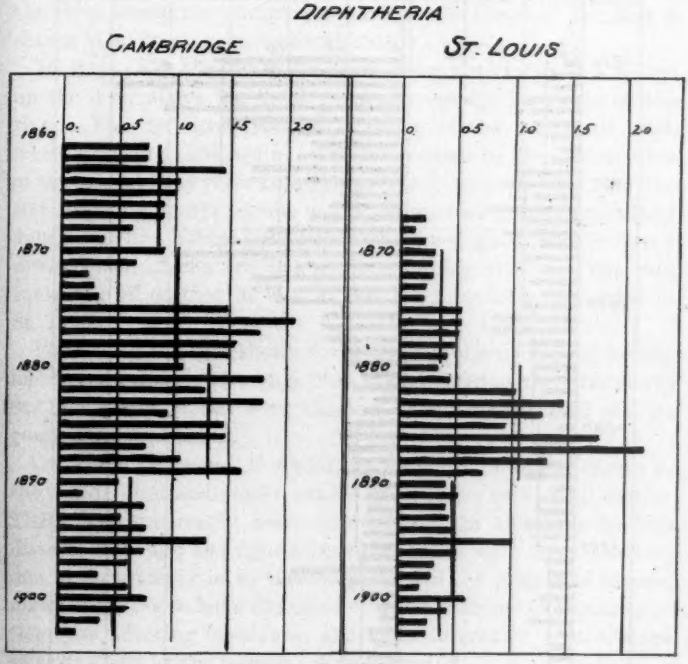

FIG. 8.

decrease of 52 per cent. St Louis shows a reduction from 1.152 to 0.435, or 62 per cent. This is undoubtedly largely due to the introduction of the antitoxin treatment. Professor Welsh states that in something like 5 000 cases of diphtheria, the history of which he examined, the use of the antitoxin treatment had reduced the mortality more than 50 per cent., while in Berlin the death-

rate from this disease was reduced from 10.2 per cent. to 3.7 per cent., and in Paris from 6.5 per cent. to 1.3 per cent.

Fig. 9 shows the death-rate from typhoid fever for Cambridge and St. Louis. In Cambridge the maximum rate occurred in

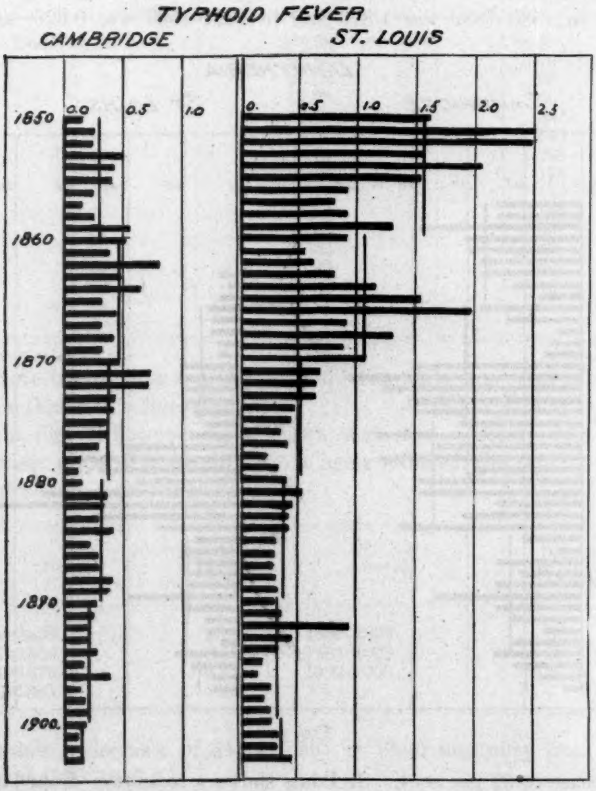

FIG. 9.

1860–1869 at 0.456 per 1 000. The rate for 1894–1903 was 0.189, a reduction of 59 per cent. The St. Louis diagram is a very instructive one, as showing the influence of the sanitary condition of the water supply on the typhoid fever death-rate.

Mr. Moore, in his paper, states that the first water works for St. Louis were built in 1832, supplying a small amount of water from the Missouri River. Most of the inhabitants used water from wells until 1855, when the water works were enlarged and a more general use of river water was made, with a decrease in the typhoid death-rate until about 1863. About this time the construction of sewers discharging into two creeks connecting with the river above the pumping station was active and its effect is shown in an increase in the death-rate.

In May, 1871, the old water works were abandoned and moved up the river above the point when any sewage then entered the river. This produced another lowering of the rate until 1890, when it began to rise again. This was caused by the introduction of sewage into the river near the pumping station. In 1892 the city set some pumps on one of the creeks which was particularly dangerous, and pumped the water which was polluted over into a sewer which discharged below the pumping station. The rate again fell off so that in 1897 it was the lowest ever recorded in St. Louis.

The rise to the rate shown for 1900 is probably caused by the increasing amounts of sewage from the six cities on the river above St. Louis, and, it has been claimed, from Chicago itself and its great drainage canal.

Consumption causes, it is said, one seventh of all the deaths in the world. In Cambridge it causes about 12 per cent. of all deaths. There has apparently been improvement in the rate for this disease, although the figures must be taken with some caution, due to uncertainty as to the correctness of the returns of causes, many objecting to have the cause of death assigned as "consumption" as affecting insurance, and other interests. The average rates as given by the returns are as follows:

Period.	Death-Rate. from Consumption	Period.	Death-Rate. from Consumption.
1850–1859	3.901	1890–1900	2.336
1860–1869	3.116	1900–1903	1.962
1870–1879	2.930	1894–1903	2.046
1880–1889	2.948		

a gain of 47 per cent.

Not only does the disease cause a formidable portion of the deaths, but its victims are largely those in middle life, the period of largest death-rate being from twenty to forty years of age.

The returns of pneumonia are so unsatisfactory that no diagram

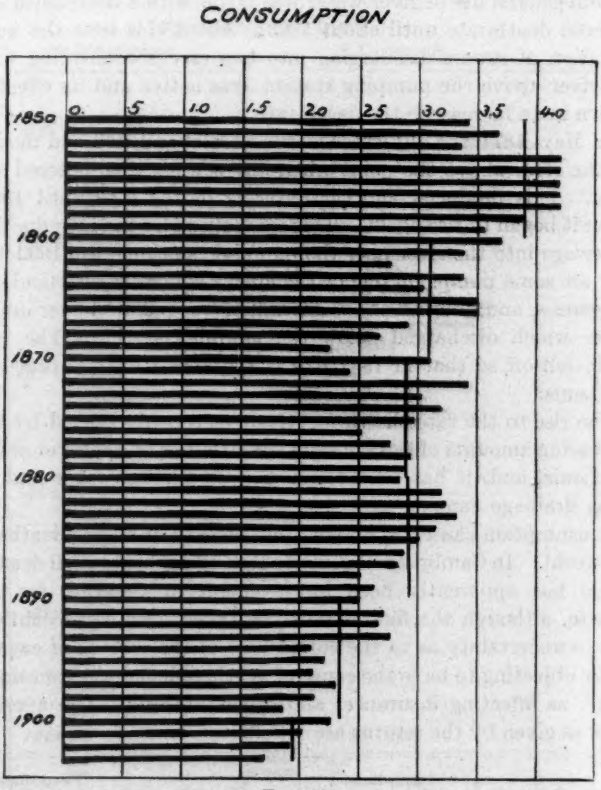

FIG. 10.

was made, — the figures as obtained, however, seem to show an increase in the rate from this disease in Cambridge. This is confirmed by the figures of St. Louis. The figures for Cambridge, as I have them, are

Period.	Death-Rate from Pneumonia.	Period.	Death-Rate from Pneumonia.
1872–1879	1.33	1890–1899	1.60
1880–1889	1.69	1900–1903	1.760

We have now seen, from the figures and diagrams presented, something of the results which have been accomplished in the last fifty years in the effort to solve the great problem of the conservation of human life.

It seems certain that in this period the danger of recurrence of great epidemics has been greatly lessened, that the mortality from many contagious diseases has been greatly reduced, and that on the whole the average length of human life has been increased. As to how far this improvement may be carried in the future, it does not seem too much to expect that, with our constantly increasing knowledge, and attention to the details of sanitary conditions and hygienic living, the improvement will continue, and that at no distant date we may have a death-rate considerably lower than the present one. We can never hope to banish *entirely* disease and death, even if it were desirable, yet there are many lines along which improvement can be made in things pertaining to public health, and by which not only may the *length of life* be increased, but its *vigor*, *activity*, and *capacity for useful work* augmented.

It does not seem, for instance, that *consumption* can for long continue the great scourge that it now is to the human race, cutting down so many in middle life, but that with all the study and investigation now being given to the pathology of this disease, it is not unlikely that some definite and efficient treatment will be found, by which the " bacillus tubercle " will be overcome and mankind will be comparatively free from this disease.

It is probable that at no distant day most, if not all, the water furnished by public water supplies will be thoroughly purified by some form of filtration, either mechanical or through layers of sand, as is now being done at Albany, Pittsburg, Philadelphia, and many foreign cities, giving a water practically free from the

" bacillus coli " and other bacteria, and thus help to materially lower the *typhoid fever* death-rate.

It may be that even the *air supply* of all buildings where people live or are employed will be purified and cleansed, and the gas, dirt, smoke, and floating germs literally washed out, as is now done at the city hall in St. Louis, Mo., reducing the liability to throat and lung diseases.

The immediate removal of *sewage* and *garbage*, and its disposal without offense and without danger, is another serious problem which should find some satisfactory solution. It may be, too, in that future time of which I speak, that *free public baths* will be furnished by all municipalities, open the year round, and that daily bathing in these, or in a private bath, will be made compulsory, the same as attendance at the public schools or vaccination now are.

Think what this would mean, from a sanitary standpoint, to the " great unwashed," to say nothing of how much it would contribute to the esthetic olefactory senses of the patrons of many of our street car lines at certain hours of the day!

It may be, too, and this seems the hardest of anything to believe or expect, that we shall some time learn to eat and drink only so much as we need, and then only of such things as are good for us. When that time comes, it may be expected that the public health will be so good that the practice of medicine will be a lost art, and these figures and mortality tables will have to be completely revised and corrected.

DISCUSSION.

PRESIDENT SEDGWICK. It has been said that the one incurable disease is old age, but when you look at the statistics you will find that only a small proportion of deaths is given as from that cause. People seem to die of everything except old age, only about 4 or 5 per cent. being put down to that. But such a percentage is apparent rather than real. A good many people die of pneumonia, for instance, who really die of old age — that is, who would not have died of pneumonia if they had not been enfeebled by age.

There are many aspects of this subject which will bear serious thought. The chart of mortality at different ages is particularly

valuable and interesting. I have one very much like it, a lantern slide, for Berlin, Germany. It is higher in the infant mortality than the one shown by Mr. Hastings. One of the striking things which appears from the study of that subject is that infants fed on cow's milk — bottle-fed infants — die at a much higher rate than those that are breast fed. There is an infinite amount of work which can be put into all these diagrams and studies.

It seems to me it is well to have such things brought before us now and then, just to remind us of the actual facts of life and of the tendencies of the times. In these tendencies this association has played an important part in Massachusetts by seeing to it that the water supplies are made purer and better; thereby reducing not only typhoid fever but some other diseases, because there is a good deal of evidence now-a-days that a number of diseases are water borne, which we did not formerly consider water borne, — not, of course, borne with the same readiness and to the same extent as typhoid fever, but still sufficiently to cause a good deal of trouble.

Mr. Frank L. Fuller. I think we owe a great deal to Mr. Hastings for the labor he has put into this paper. The results of his work are very instructive indeed and will be very valuable and interesting for purposes of future reference and comparison. I should like to ask Mr. Hastings whether he has made an enumeration of deaths from accidental causes.

Mr. Hastings. No, sir; I didn't go into that.

Mr. H. A. Miller. I understand that the death-rate among infants was much greater formerly than in later years, and at the same time the birth-rate has decreased. If the birth-rate had remained as it was, would the death-rate have remained the same, or would it have been greater or less?

Mr. Hastings. The death-rate I gave for infants was for the infants living, so it wouldn't make any difference how many there were, the rate would be the same. The diagram I showed you gave the death-rate of children under one year, living at that age, and the death-rate of children under two years, living at that age, so the number would not have any effect.

Mr. Miller. I probably did not make myself understood. The death-rate among infants, as I understand it, is smaller than it used to be, while the birth-rate also has decreased. That is, you

gave us the total death-rate of all ages, as I remember, and that has decreased?

MR. HASTINGS. Yes, sir.

MR. MILLER. Now, if the birth-rate had remained normal, or remained the same as it originally was, would the death-rate total be in proportion, or would it have decreased as shown by you? Do you get an idea of what I mean?

MR. HASTINGS. I think so. I think if there had been more children the death-rate of all ages would have been higher, because the mortality among children is larger.

MR. MILLER. Would it have been the same practically as it was originally?

MR. HASTINGS. I couldn't say as to that, but I don't think so.

THE PRESIDENT. Perhaps I may say a word about that, as I happen to be more or less familiar with the subject. A high birth-rate is generally supposed to favor a high death-rate, and yet, if the birth-rate had remained as it used to be, it is not likely that the infant death-rate would have been as high as it then was; although it would have been higher than it now is.

MR. DESMOND FITZGERALD. I will say a single word in regard to the population curve shown on the diagram. Some time ago I had occasion to examine very carefully the increase in population of all the principal cities of the United States for the city of Oakland, Cal., on a subject connected with their sanitary works, and I found that of all the cities in the United States the city of Worcester had increased from the beginning of its records to the present time in the most regular way, showing an almost perfect curve. The city of Providence, I think, came next, and was very similar.

MR. ROBERT J. THOMAS. I should like to ask whether in taking the population of Cambridge the students in Harvard College were included?

MR. HASTINGS. I think so. They are enrolled as living in Cambridge, although very few are voters there. There has been quite a discussion about that, whether students who are enrolled as inhabitants of Cambridge really have a domicile or residence there. They are included as inhabitants, but, generally, not as voters.

MR. THOMAS. They come into the population statistics?

MR. HASTINGS. Yes; and that would explain somewhat the rate

of our increase in population. We have about 5 000 students, and they are not expected to contribute much to the birth-rate.

THE PRESIDENT. Mr. Mills has drawn a very interesting curve for Lawrence, by which he has shown that the introduction of the filter in 1893 was followed by a very marked increase of population and decrease of the total deaths. It is one of the most instructive curves I have ever seen. I do not remember the exact figures, but the gist of it is that, assuming the total number of deaths in Lawrence in 1892 as 1 000, and it was going rapidly up by a line which would diagonalize that chart, when the filter was introduced the line changed its direction altogether, so that after ten years the total number of deaths in the city was no greater than it had been in 1892, and that, too, although the population had increased meantime 50 per cent. It is a very extraordinary showing as to the effect of a purified water supply upon the public health.

MR. MORRIS KNOWLES.* There is something which occurs to me, which may be of interest in teaching us not to draw conclusions too quickly, unless we know all the facts. An instance which occurred in our city of Pittsburg during the last year illustrates this. As you all know, it is the city which leads all others in death-rate and sickness from typhoid fever. For some years past the average reported cases of sickness per 100 000 has been 750 to 800, and the cases are generally recorded. During the past year, through the energetic efforts of the head of the bureau of health, it has been made manifest to every one that it is not wise to drink water from the municipal supply. Notices have been posted in the street cars and in the public buildings, office buildings and other places, that the city water should be boiled before it is used for drinking. In buildings where good water is furnished, that fact is placarded, so that people will know that the water is safe.

Now it is not probable that there has really been a twofold increase in the number of typhoid cases within the past few years. There has probably been some increase, but I doubt if the increase has been anything like what it appears from the statistics to have been this year. The statistics so far show that there have been about twice as many cases of typhoid fever in the city as ever before. In other words, instead of being 750 or 800, there will probably be

* Chief of the Bureau of Filtration, Pittsburg, Pa.

reported 1 400 per 100 000, while the deaths will remain about the same as heretofore; that is, the death-rate this year will be about 10 per cent. instead of 15 to 18 per cent. The probable explanation is that it is popular now to report diseases as typhoid which are doubtful; and formerly not all were reported which should have been, and it shows that it is not always safe to trust statistics unless one knows the facts.

THE PRESIDENT. That applies to cases rather than to deaths, because deaths are much more accurately reported.

MR. CHARLES R. FELTON.* It is astonishing how closely you may predict from a population curve what the future population of a city will be, at least we have found it so in Brockton. We have had a curve plotted for several years, and have come remarkably close in our predictions on the last three censuses. Just prior to our last census the reporters, in attempting to forecast what it would show, interviewed me, and I simply referred to the chart and predicted a population of 48 000. After the first returns came in the reporters joked me a little on having missed it because I was 18 off. I said there must be some mistake, and our later returns gave us within 6 of my figure.

* City Engineer, Brockton, Mass.

ON THE PROTECTION OF PUBLIC WATER SUPPLIES FROM POLLUTION DURING THE CONSTRUCTION, MAINTENANCE, AND OPERATION OF RAILROADS, WITH SPECIAL REFERENCE TO THE WATER SUPPLY OF SEATTLE, WASHINGTON; TOGETHER WITH CRITICISMS OF THE PRESENT METHODS OF WATER SUPPLY AND SEWERAGE OF RAILWAY TRAINS.

BY WILLIAM T. SEDGWICK, PROFESSOR IN THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY, BOSTON, MASS.

[*Read September 14, 1906.*]

In an address before the New England Railroad Club, in Boston, in November, 1899, the author drew the attention of railway managers to the unsanitary and objectionable practice of allowing the droppings of the closets of passenger cars to be scattered all along the lines, polluting the trucks and roadbed, and to a greater or less extent the air, the soil, or water in the vicinity. Since that time other writers have touched on the same subject, but for one reason or another it has as yet received but little attention.

Railways, both steam and electric, in rapidly increasing numbers, have been constructed, maintained, and operated upon the collecting grounds, alongside the principal tributaries, and even over portions of the storage reservoirs, of numerous water supplies, without exciting more than occasional comment or protest. Suddenly and unexpectedly within the last few months the whole subject has been brought to the front by the proposed construction of a great transcontinental railway close alongside a mountain stream used without filtration or storage as the water supply of a large and rapidly growing American city, namely, the city of Seattle, Washington. The Chicago, Milwaukee & St. Paul Railway, in seeking entrance to Seattle, after having selected the Snoqualmie Pass as the proper place for crossing the lofty Cascade Mountains, found the best route from the pass to that city to be one which for 11 miles runs through the valley and very near the shores of

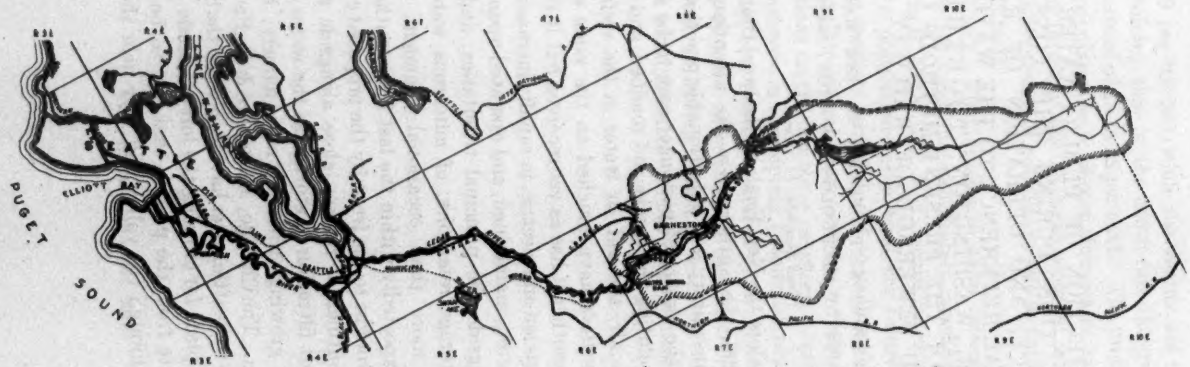

FIG. 1.—MAP SHOWING PROPOSED ROUTE OF CHICAGO, MILWAUKEE & ST. PAUL RAILWAY, THROUGH CEDAR RIVER WATERSHED. (SCALE ABOUT 8 MILES TO AN INCH.)

Cedar River, the source of the public water supply of Seattle, as shown on the map, Fig. 1. Much of the land bordering Cedar River is owned by the city of Seattle, having been purchased under the advice of its able and intelligent city engineer, Mr. R. H. Thomson, for the express purpose of protecting the watershed. Hence it became necessary for the railroad to obtain from the city a right of way over this land. This was arranged to be done by means of an ordinance requiring the mayor to sign deeds for such a right of way 100 feet wide and 11 miles long through the watershed and for most of the way very near the river. Such an ordinance was accordingly drawn up, passed by the city council on May 21, and approved by the mayor on June 5 of the present year (1906).

This ordinance marks the beginning of a new epoch in the relation of railways to public water supplies, and hence deserves thorough and careful consideration. As far as I am aware, it is the first example on record of the frank recognition of the dangers involved in the construction, maintenance, and operation of a railway along the shores of a public water supply, together with explicit and extensive provisions for meeting them. I make no apology, therefore, for quoting from it at length. It is entitled:

"ORDINANCE NO. 13 836.

"An ordinance granting to the Chicago, Milwaukee & St. Paul Railway Company of Washington, its successors and assigns, a right of way one hundred (100) feet in width for the location, construction, maintenance, and operation of a railroad across and through lands owned by the city of Seattle, in the county of King, state of Washington, and authorizing the execution and delivery of a conveyance of such right of way. Be it ordained by the city of Seattle as follows:

"SECTION 1. That there be, and hereby is, granted to the Chicago, Milwaukee & St. Paul Railway Company of Washington, its successors and assigns, a right of way, in perpetuity, for the location, construction, maintenance, and operation of a railroad upon, across, and through the lands owned by the city of Seattle, in the county of King, state of Washington, one hundred (100) feet in width, being fifty (50) feet of such width on each side of the center line of the railroad of said company as located and staked out upon the ground, which lands are described as follows, to wit: . . .

" Provided, however, that nothing in this ordinance contained shall be construed to grant any right to said railway company, its successors or assigns, to occupy or use the bed of the stream of Cedar River, or any portion thereof, or any of its tributaries, except so far as herein authorized for the purpose of constructing and maintaining bridges across said river or for the purpose of constructing and maintaining embankments for the roadbed of said railroad.

" SECT. 2. The grant of the right of way herein contained is upon and subject to the following conditions, to wit:

" 1. Said grantee shall begin the construction of its railroad upon the right of way herein granted within one (1) year. . . .

" 2. No station shall be established or maintained by said railway company, its successors or assigns, between the city intake and the easterly terminus of the right of way herein granted without the consent of the city of Seattle first having been granted by ordinance.

" 3. While the said right of way is being cleared and prepared, and during the construction of said railroad thereon, the camps or living quarters of the men engaged in such work, and the accommodations for any animals employed thereon, shall be located and maintained at such distance from said Cedar River, in good sanitary condition, as shall be approved by said city of Seattle.

" 4. The grantee, its successors and assigns, shall locate the living quarters of any and all employees engaged in the care and maintenance of the railroad constructed upon the right of way herein granted, or in the operation and maintenance of any side or passing tracks, water tanks, telegraph or block signal stations or towers, or other appliances, constructed and maintained upon said right of way, at such distance from Cedar River as shall be approved by the city of Seattle, and shall maintain such living quarters in good sanitary condition.

" 5. The said city of Seattle may employ an inspector to patrol or inspect the work of construction of the said railroad upon said right of way for the purpose of ascertaining whether said work is being prosecuted in accordance with the conditions herein contained, and said grantee agrees to pay the cost of such inspection."

Then follows a location of the bridges to be built, with a provision at the end as follows:

" All bridges constructed upon said right of way across any creeks or streams intersecting said right of way shall be solid-decked structures, and all bridges, trestles, and approaches shall be constructed and maintained so as to prevent any foreign matter

from dropping from engines, cars, or trains passing over the same into Cedar River or into the creek or streams running into said river.

"7. Said grantee, its successors and assigns, shall not, during the construction of said railroad, or thereafter in the maintenance or operation thereof, place, throw or deposit, or permit the placing, throwing, or depositing in said Cedar River, or in any creeks or streams running into said river, or upon any ground adjacent to said river, any offensive or deleterious matter which may cause the pollution of the waters of said streams, and said grantee, its successors and assigns, shall at all times maintain the right of way herein granted, and the railroad constructed thereon, in such manner as not to cause any pollution to said stream."

Further on is a section in which it is provided that if the railroad, in order to avoid curves of more than 3 degrees, finds it necessary to go into the river,—

"Embankments required for the proper support of said roadbed may be extended into the bed of the stream, provided that such embankments shall be built of such material and in such manner as to avoid pollution of the waters of said river, and so as to prevent the escape or passage of offensive matter from or over said embankments into the said river."

Finally, there is a section not only authorizing the mayor and comptroller, but directing them, "upon the taking effect of this ordinance, to execute and deliver to said grantee a deed conveying in perpetuity . . . the right of way herein granted . . . for the construction, maintenance, and operation of said railroad. . . ."

The ordinance was passed by the city council on May 21, 1906, and approved by the mayor on June 5. It thereupon became incumbent upon the mayor to issue the deeds by which the railroad should acquire the right of way, and it was supposed that such deeds would issue without delay. Up to this time there had been no open opposition to the plan, the ordinance having been prepared by the legal representatives of the railroad company and the city officials, acting together. I am assured by the railroad officials that it was their intention to protect the water supply in every possible way, and that they believed they had fully and adequately done so by the provisions contained in the ordinance.

Not long after the mayor had signed the ordinance, but before he had signed any of the deeds contemplated under it, an agitation arose in the city, alleging that the water supply, instead of being safeguarded by the ordinance, was in reality seriously endangered by it, inasmuch as the building of the railway must of necessity bring into the valley hundreds of laborers of an uncleanly type, who would inevitably pollute the river, while its maintenance and operation necessarily involved the temporary or permanent presence in the watershed of section hands, signal men, trainmen, wrecking gangs, and others, not to mention the thousands of passengers who would annually travel on the road and use the car closets, spit from the car windows, or otherwise contaminate the watershed.

This agitation rapidly grew to large proportions, being participated in by physicians, labor organizations, women's clubs, the Chamber of Commerce, good government clubs, and other public bodies, and before long culminated in an order issued by court on application of the King County Medical Society, composed of physicians in Seattle and vicinity, restraining the mayor from signing the deeds. I am informed that the legal representatives of the railroad, who supposed that they had amply and even generously provided for the protection of the water supply, were nonplussed at this sudden outbreak of popular feeling, and unable to understand why it had arisen, or why it should have reached such proportions. Of the reality or extent of the objections there was, however, no doubt, and in self-defense against the popular storm the authorities of the railroad secured the services of several experts to investigate the subject and report to them upon the question whether the railroad could or could not be built, maintained, and operated in Cedar Valley, as proposed under the ordinance, without endangering the purity of the public water supply of Seattle. These included Mr. J. W. Alvord, civil engineer, a member of this Association; Professor Pammel, of the Iowa State University; Professor Bissell, of the Mechanical Engineering Department of the same institution; Prof. E. G. Smith, of Beloit College, and afterward the writer. Mr. Alvord, Professor Pammel, and Professor Bissell in due time made their reports, and a brief summary of Mr. Alvord's report

appeared in the *Engineering News*, page 238, August 30, 1906; the complete report follows as an appendix (A), page 442, to this paper. These reports threw much light on the situation but did not appear to the citizens to settle the question, and hence did not calm the popular storm.

The citizens of Seattle had long supposed that in Cedar River they possessed a perfect water supply, for Cedar River is a beautiful stream, running through a virtually uninhabited district, and forming the outlet of Cedar Lake, a large sheet of water lying, remote and almost inaccessible, 1 500 feet above the city in the Cascade Mountains. It is surrounded by mountains rising several thousand feet about it, — a lake probably as beautiful as is Lake George. When, therefore, Mr. Alvord showed that there were a number of logging camps on the watershed with very defective sanitary appliances, practically draining directly into the stream or its tributaries; when he further showed that the sawmill camp of Barneston, having about one hundred and twenty people, partly Asiatics, connected with it, was virtually draining into the stream, and that similar nuisances existed elsewhere on the watershed, the people of Seattle were surprised and greatly annoyed. The conclusion of Messrs. Alvord, Pammel, and Bissell, briefly stated, was that the water supply was already far from perfect, that the railroad could be safely built through the valley, and that it would not be as much endangered by the coming of the railroad as it was already endangered by existing nuisances.

Professor Smith arrived on the ground somewhat later than Mr. Alvord, Professor Pammel, and Professor Bissell, and proceeded to make his own investigations. The author arrived later still, but even before he had come the physicians and other objectors to the ordinance had expressed their readiness to accept as final the opinion of any one whom they considered as an unprejudiced expert, or of any group of such experts, regarding the question at issue. After considerable discussion and delay it was agreed on all sides to leave the settlement of the matter to a commission consisting of Dr. A. C. Abbott, Professor of Hygiene in the University of Pennsylvania and health officer of the city of Philadelphia, on behalf of the city of Seattle; Dr. Charles Harrington, Professor of Hygiene in Harvard University, and secretary of the State

Board of Health of Massachusetts, on behalf of the King County Medical Society; and the writer, on behalf of the railway company. Meantime, Mr. John R. Freeman, the eminent hydraulic and sanitary engineer, who fortunately happened to be passing through Seattle on his way to Alaska, was prevailed upon to visit the watershed with some of the other experts and to make a special report on the subject to the State Board of Health of Washington which, through its energetic and able secretary, Dr. E. C. Heg, had already taken an active interest in the problem and had instructed its engineer, Prof. W. J. Roberts, of Pullman, Wash., to make an independent investigation.

As a matter of record and for convenience of reference, the report of the commissioners, Mr. Alvord's report, and Mr. Freeman's report are printed as appendixes to this paper, and since these cover completely and in detail all the points at issue I need not here dwell further upon these. There still remain, however, certain other important aspects of the relation of railroads to water supplies which deserve our careful consideration.

THE WATER SUPPLY AND SEWERAGE OF RAILWAY TRAINS.

As I have already said, as long ago as 1899 I urged the members of the New England Railroad Club to devise some better methods of disposing of excrements than those now customary on railroad trains. I dwelt also at much length upon the need of improved water-supply arrangements — a subject which still deserves the closest attention. Through cars are often run great distances, passing through various cities and towns en route, and receiving from time to time fresh supplies of water. It may, therefore, easily happen that if any one of these supplies is impure, the water tanks shall become contaminated, and persons traveling in the car, or even joining it at stations which have excellent water supplies, may be exposed to the danger of contracting disease. I have myself had offered to me in a dining car in New England a clayey water which had obviously been taken into the water tanks on the previous day when the water supply of the car had been replenished in Washington, D. C. To a very much less extent travelers may be exposed to similar dangers from contaminated ice.

The importance of the distribution of contaminated water

from large centers such as Chicago, Cleveland, Pittsburg, and Washington, having now or having recently had polluted water supplies, is very great, and well deserves the keenest attention of epidemiologists, especially of those who have been puzzled to explain the excess of typhoid fever in the United States over that in other civilized countries, such as England and Germany. At the same time the railroad companies can hardly be blamed for filling their water tanks from any accessible water supplies which are locally deemed good enough for the use of the public.

There still remains, moreover, a feature of the method used for water supply within the cars themselves which calls for serious criticism, and that is the use of the common drinking cup which here, as always, is a well-known sanitary abomination. A dozen or more years ago it was the almost universal custom on American railways for one of the brakemen to carry through the cars a tin can to which were attached a couple of removable cups or glasses. These were used in turn by thirsty passengers who remained in their seats, the glasses being filled for them by the brakeman as he paused for the purpose. This practice is now largely done away, and in its place a single cup or glass is kept under a fixed water tank, from which a jet of water can readily be drawn into the cup or tumbler, which is thus intended to serve the wants of the population of an entire car. Any one who thinks that this plan of meeting the water-supply needs of a large number of people of all sorts is either attractive or wholesome, has only to sit near the water tank of a crowded excursion train on some hot summer day, especially if the car is filled with mothers and young children, in order to be quickly convinced that a reform is here urgently demanded. Few things are more trying to a sanitarian than to observe a series of thirsty passengers of all degrees of cleanness and uncleanness applying their lips in succession to one and the same tumbler which is seldom, if ever, even rinsed between times. Wholly apart from the question of the quality of the water furnished, the opportunity here provided for the exchange of disease germs must be apparent to any one, and I need not further enlarge upon this custom, which is both familiar and disgusting.

A remedy might easily be found by having the faucet of the water tank bent upward and provided with a special orifice so

that a small jet should rise for an inch or so above its tip, thereby furnishing a "sanitary fountain" similar to those which, in increasing numbers, are being provided in parks, playgrounds, gymnasia, schools, and other places where many persons must, of necessity, drink from a common supply. Travelers should also be encouraged to bring with them on railways their own private drinking cups.

Criticisms have frequently been made of the filling of the water tanks and the handling of broken pieces of ice for the tanks by employees whose hands are far from clean, and it must be admitted that the whole matter of the water supply and ice supply of passenger trains frequently leaves much to be desired in the way of sanitary improvement.

As for the sewerage of trains, within a few years, and from motives of mere decency, the custom has become general of locking the closets for the purpose of excluding passengers from them on trains approaching or standing at important stations, a practice which, as will be explained beyond, while certainly contributing to the cleanness of the station platforms, is decidedly objectionable on hygienic grounds. Only in very rare cases, however, so far as I am aware, are the closets of the numerous passenger trains on a great trunk line kept locked for several miles while approaching and after leaving a station, not for decency's sake but in order to protect a public water supply.

Near the city of New Haven, Conn., many travelers have noticed that the closets on the Pullman and other cars going east are kept locked after leaving that city until Branford, nine miles away, has been passed. Going west, the closets are locked as the trains approach Branford and are not unlocked until after leaving the New Haven station. I am informed that the reason for this practice is that some two or three years ago inspectors employed by the New Haven Water Company, while patrolling the Lake Saltonstall watershed near Branford, observed and reported upon the presence of fecal matter on the rails or roadbed, very near the intake of the Lake Saltonstall supply of the water company, which company thereupon complained to the railway officials,who issued an order requiring all closets to be kept locked on trains traveling between Branford and New Haven. I am

also informed that a similar rule requires the locking of all closets on trains on the Northampton Division of the same road between New Haven and Cheshire, a distance of fifteen and one-half miles, for the better protection of another supply of the New Haven Water Company, the Lake Whitney supply.

I have been unable, however, to find that any similar precautions are taken in regard to freight trainmen. On the contrary, inquiries have shown that on our eastern railroads the freight brakemen and trainmen have to get along the best way they can in answering the calls of nature. I am told that in the West there is generally a closet in the caboose for the use of these men, but that near Boston the crews of freight trains either make use of empty box cars, which they defile at their convenience or necessity, or of the coal pile in the tender; or that, when taken hurriedly, they even use as a seat the couplings or bars connecting the cars — obviously an uncomfortable and dangerous practice, especially when the train is moving rapidly. All of these facts further illustrate the crudity and primitive character of the sanitary arrangements of our American railway trains, for, obviously, no occasional locking of closets on passenger trains will ever be more than a partial and very superficial remedy of the present crying evils.

The New Haven case is the only one of which I have heard in which definite fecal pollution of the rails was observed near a water supply, or in which any similar observation led to an immediate attempt at reform. I have recently learned, however, from Mr. R. W. Pratt, chief engineer of the State Board of Health of Ohio, of a case, not exactly identical with the New Haven case, but so nearly in the same category that I have asked him to give me a statement of it, which he has kindly done, and which he permits me to quote here:

"The village of Plymouth, Ohio, has, until recently, used as a partial source of water supply a small tributary of the Huron River. Water was taken at a point a short distance southeast of the village, immediately north of, and very near, the Northern Ohio Railroad bridge, which spans this tributary stream or creek. Two hundred feet west of the creek, and twenty or thirty feet above it, adjacent to the railroad, is a water tank used for railroad pur-

poses. A small gully runs from the tank to the stream, which it enters just above the intake.

"In June, 1905, during an inspection of the public water supply by a representative of the Ohio State Board of Health, an eastbound train, composed of freight cars, cattle cars, and one passenger coach, stopped at the tank to take water. After filling the locomotive tender, the train slowly passed on to such a point that the forward cattle car was brought directly opposite the tank. The day being hot, the animals were badly in need of water. In order to water them, a brakeman swung the spout of the water tank directly into the car, turned on the water and signaled for the locomotive to move slowly forward. By this procedure the cattle and hogs in the several cars were given a generous shower bath, while much of the accumulated filth in the bottom of the cars was flushed out into the gully by the side of the track, through which it flowed rapidly down to the creek, quickly entering the latter at a point not more than fifty feet above the intake of the Plymouth water supply.

"Inquiry showed that this was a common practice on the part of the railroad men during warm weather. It should be added, however, that the railroad officials, when the matter was brought to their attention, agreed to see that the practice was discontinued; and that the village has recently taken steps to procure a sufficient water supply from other sources, so that the use of the creek water will not be necessary in the future."

This case seems to me to be a very important contribution to the literature on this subject, which at best is but scanty, for I may say parenthetically that I have examined English and German authorities and have found nothing of any consequence in them on this subject. One would, perhaps, not expect to find much in such works, because foreigners, as a rule, use closets at stations, leaving the trains when necessary for that purpose. It is, generally speaking, only on the fastest trains that closets are provided, and from a German work on railway hygiene, published in 1904, it appears that the discharge pipes from the closets of German express trains discharge their droppings upon the roadbed precisely as ours do.

Finally, quite apart from the matter of sewage disposal, let us consider briefly the hygienic aspect of locked closets on railways. In the first place, although it is true that our commission recommended the locking of the closets while trains were going through

the Seattle watershed, we did not depend upon such locking as an entire safeguard, and I do not believe that locking ever will be a complete safeguard. There are times when people are ill, when they simply *must* get access to the closets. There are times when persons so imperatively require to get into the closets that they will tip the porter heavily, or do almost anything, in order to obtain admittance. And they ought to obtain entrance. It is a hardship, and worse, not to allow access to the closets, the locking of which must be pronounced, once and for all, an imperfect, crude, and, not infrequently, an absolutely barbarous device. The practice is rude and unhygienic, even in its least objectionable form of locking the closets only while the train halts at stations. For any longer period, as for example, while trains are covering the distance from New Haven to Cheshire or New Haven to Branford or *vice versa*, it is much worse.

Moreover, the practice is not only barbarous and unhygienic, it is often ineffective. How is anybody going to be driven out of a closet at the right time if he is already in it before the train arrives at New Haven going east, or at Branford going west? I have myself, while observing the actual working of this regulation, been informed by a porter as we passed by the New Haven intake near Branford that he could not lock a closet as "there is somebody in it." The regulation is clearly ineffective and unworthy of modern industrial organization. It must be done away with, and that at the earliest possible moment.

As to the dropping of the excreta through the discharge pipe upon the roadbed, this, also, is a crude, unsatisfactory, and unsanitary way of disposing of excreta on trains. At best it necessarily soils the track and the trucks, for the section hands and others to walk or to work upon; it sometimes endangers public supplies of water; it always pollutes the air, and under some circumstances, by being carried by section laborers or others on their hands to their homes, endangers persons not immediately in contact with the roadbed or rolling stock.

But, it will be asked, what can be done about the matter? The answer is that the time has come when we must insist that if a railroad company finds it practicable to carry large iron tanks under passenger cars for gas or for refrigerator purposes, it can and must

also carry there an iron tank for sewage. If for any reason this is impracticable, earth closets with pails frequently changed may be used. Railroads must somehow cease distributing fecal and urinary matters all along their lines. The closets ought not to be shut up, either at stations or anywhere else, so that the all-important personal hygienic requirements are defeated. The sewage tanks or pails could be emptied at selected places, either at the end of the run or, on long runs, at principal stations, precisely as water and gas are now taken into special tanks at principal stations. Of course there would have to be disinfection from time to time, and some trouble would have to be taken to see that the sewage tanks were kept clean and free from smells, but this could be done and ought to be done. At any rate, something different from the present crude, disgusting, and dangerous practice must be devised. And, where railroads run over or very near water supplies, as they often do and often must, if common decency and the comfort of the men are not enough to secure it, some provision must also be required for the convenience of freight trainmen. Upon wrecking trains and repair trains it would be easy enough to carry a portable closet, or a fixed privy with earth closet beneath, so that all excrements should later be carried off from the watershed and deposited at a distance.

I am aware, of course, that tanks underneath the cars would, in winter, be exposed to freezing, and that special pains would have to be taken to prevent this. It will not be as easy, certainly, to get rid of the excreta in a decent and scientific way, as it is simply to let them drop down through a hole in the floor; but we have got through dropping excreta in that way in our houses and hotels, and we must stop doing it in our traveling houses or hotels, that is, in our passenger cars. Water-works authorities, especially, must insist that whenever a railroad passes over a watershed it shall be subject to regulations regarding the discharge of excreta not less stringent than those which would be applied to an hotel or other place of public resort situated on the same watershed.

(As this paper is passing through the press, my attention is drawn to a newspaper statement touching another aspect of the sanitation of railway trains, namely, their garbage disposal:

"It was a surprise to me last week to see, just below the picturesque stone bridge which crosses the main street of ——, a trap for maladies of some sort, if not for typhoid. On the narrow roadbed, and almost covering the railway tracks, were strewn refuse of all kinds, soiled papers, fragments of cooking — in short, all the débris of human life that makes excellent food for pigs, with streams of dirty water forming pools that might sink into the soil eventually, but at present were stagnant. The spectacle gave me a jolt. It was so foreign to the general impression one receives of prosperous —— above ground, and it was wondered how such a garbage hole could ever be overlooked by the powers that be. No doubt this blot on the railroad banks has escaped the management's eagle eye."

Doubtless some of the employees upon dining cars and other departments of railway service look upon railways very much as some Americans look upon their streets, namely, as being practically waste baskets, garbage pails, and sewers. In all these matters our people are generally uneducated and careless. In the city of Boston the police commissioner has lately set a commendable example by ordering the arrest of all persons misusing the public ways in the manner just described, and a similar solicitude for the sanitary care of our railways on the part of railroad officials would doubtless effect a corresponding reform.)

APPENDIX A.

REPORT TO THE CHICAGO, MILWAUKEE & ST. PAUL RAILWAY COMPANY OF WASHINGTON, UPON THE SANITARY SITUATION CREATED BY THE PROPOSED CONSTRUCTION, MAINTENANCE, AND OPERATION OF ITS LINE THROUGH A PORTION OF THE COLLECTING GROUNDS OF THE PUBLIC WATER SUPPLY OF THE CITY OF SEATTLE.

BY JOHN W. ALVORD, CONSULTING ENGINEER.

At your request I have examined a large portion of the Cedar River watershed, the projected line of your railway, and the sanitary situation occasioned by its construction and operation. For this purpose, in company with Professor Bissell and Professor Pammel, of Ames, Ia., a week was spent in an examination of the territory in question.

During this trip we were accompanied by the division engineer of your company, Mr. Wilson, who pointed out the proposed location of the track from the company's plans and profiles. On Monday, the 16th of July, we entered the watershed by way of North Bend, examined the sanitary situation at the city's power house, and from thence drove up to the outlet of Cedar Lake, examining its shores in the vicinity of the outlet and at the outlet works in general. We then returned to the power house and commenced a detailed examination of the located line of your railroad from the power house to the city intake, measuring at frequent intervals the distances of the center line of the right of way from the water's edge, noting the soil conditions and other data. That portion of the line between the power house and Barneston is quite accessible for examination and was easily covered in the afternoon of the 16th.

DIFFICULT TO TRAVERSE.

We spent the night of the 16th at Barneston, and the next morning continued down the line of the right-of-way from Barneston to the city's intake. This portion of the line is inaccessible

and difficult, the surveyors' line passing through heavy timber and dense underbrush and over many fallen logs and other impediments. The night of the 17th we spent at Ravensdale, and on the morning of the 18th took horses for Kangley, noting soil conditions, habitations and other data at that point, and the terminus of an interesting creek which lost itself in the porous soil just west of that station. We spent the night of the 18th at Barneston.

On the 19th we proceeded afoot by forest trail to the line of the Columbia & Puget Sound Railway, near Weyerhauser's logging camp No. 4. From there we proceeded to the Denny-Clay Company's works, the logging camps in the immediate vicinity, and the settlement at Sherwood. We continued from there to Walsh Lake and returned to Barneston that night. On the 20th we covered the territory drained by Taylor Creek, visiting Miller's logging camps Nos. 3, 5, and 6, also the intake and dam of the Barneston water supply on Taylor Creek and the shingle mill about a mile south of Barneston. On the 21st we noted the sanitary conditions around Barneston, and took the train for Seattle.

At the time the Seattle water works were first constructed I also visited this watershed in the interests of those who were expecting to take the bonds of the project, becoming fairly familiar with the topographic conditions of that section.

THE WATERSHED.

The watershed of the Cedar River above the intake appears to be one of the most extensive areas of porous soil utilized for natural filtration of a public water supply which it has ever been my fortune to observe. The glacial drift of which it is composed consists of coarse and fine gravels intermingled to a depth of some hundreds of feet. We looked in vain for traces of clays or finer soils. The surface mold is thin for the most part, and the level of the soil water on the benches and plateaus back from the river is evidently at a great distance below the surface, as indicated by the location of springs and the depth of the eroded streams. There is little or no surface run-off of the rainfall. Numerous potholes exist, depressions without visible outlet, and there was scarcely observed a dry run of any kind, or rivulet, save those of

running streams, few in number, which were marked upon our map.

The unusual porosity of the soil may be best illustrated by the statement that in passing over the located line of the railway, eleven miles along Cedar River, no run or rivulet or surface indication of wash of any kind was observed leading into the stream, which would indicate that the rainfall passed over the surface of the ground. We also observed that in passing over the Northern Pacific Railway, which crosses the watershed from north to south, no pains were taken by that company to ditch its tracks, to provide small culverts, or even, in the case of very considerable depressions, to arrange for the passage of water from one side of its embankment to the other. The soil, therefore, of this valley is a porous one, receiving the copious rainfall of this region and largely absorbing it, and by slow percolation filtering it to an unusual degree, thus creating the clear streams and exceptionally pure water.

POPULATION OF THE WATERSHED.

As nearly as our inquiries could determine, the population of this watershed is about 1 500 people, mostly employees of the various logging companies living in camps and concentrated at certain points along the small streams which are tributary to the Cedar River. This class of population is perhaps not the most desirable from a sanitary point of view, and their environment and situation, as we saw it, is not attractive. The camps are serving generous quantities of food to the men, much of which is wasted, and in order to dispose of this refuse in any considerable camp a dozen or more hogs are kept and fattened from the garbage of the camp. The hog pens invariably extend into the running stream, so that the hogs may water there at will.

We observed contamination of this character at Miller's Camp No. 5, situated on the north fork of Taylor Creek. This camp is working at the present time about 60 men. The liquid refuse of the kitchen is delivered immediately upon the bank of the creek, and the hog-pen is situated so that the hogs have direct access and were observed fouling the creek. The creek has a flow estimated at from 4½ to 5½ cubic feet a second, and is distant from the intake approximately 15⅜ miles, measured along the flowing

streams. Such flow measurements as we made indicated that the rapidity of the stream was in no case less than a mile an hour, and often exceeded 2 miles an hour, the fall being very great.

LOGGERS POLLUTE THE WATER.

At Miller's Camp No. 3, working now about 15 or 18 men, there were two privies and a garbage pile in the immediate vicinity of the stream, so situated as to pollute the same. An old, abandoned camp in the northern part of section 30, township 22, range 8 east, showed traces of pollutions in the vicinity of Taylor Creek in the shape of carcass remains, garbage piles, and privies. This camp was about 400 feet from the stream, however, the ground sloping down to the creek.

Miller's Camp No. 6, working 65 men, is situated upon a side hill a considerable distance from running water, the water supply being pumped up from a spring some 2 000 feet lower down upon the slope. Pollutions at this camp, which were similar in all respects to the other camps observed, would, therefore, not be a sanitary menace. At Kangley there are habitations and a saw-mill, and the pollutions similar in all respects to the other camps observed were drained by a flowing brook running past the station. This stream pursues its course to a point about one-half mile below the station, and although flowing an amount of water estimated at 8 or 10 cubic feet per second, disappears entirely into the porous soil and sink-holes in that vicinity.

At Weyerhauser's Camp No. 4, situated on a stream flowing about 5 cubic feet per second and running into Rock Creek, there is a logging camp, with some 6 bunk-houses located immediately over the brook, and garbage piles and privies immediately adjacent to the same. Below the camp a hog pen, containing 15 hogs, was so situated that the stream was enclosed, creating conditions which were far from desirable. The distance from this source of pollution to the intake, measured along the line of the flowing stream, is $5\frac{7}{8}$ miles.

At the Denny Clay Company's works we were told that there were about 100 men at work and probably 500 people in the vicinity. There are perhaps 25 houses of all kinds, besides the company's plant, including a considerable camp, sewered into a small

rivulet flowing, at the time of our visit, perhaps 1½ cubic feet per second, and draining into Webster Creek.

Proceeding down to Walsh Lake we found upon its banks a log-loading outfit immediately adjacent to the mouth of Webster Creek. We observed at this point that the loggers themselves were not in the habit of drinking the water from this brook, but obtained their drinking water from a spring some twenty-five minutes' walk up the railroad. Walsh Lake has fairly good shores, although considerable decaying timber is found about the lake, as is the case with all other lakes and streams in this country. Three habitations were observed on the opposite banks of the lake which appeared to be occupied. Each habitation was provided with barns, etc., which apparently drained into the lake. Persons were observed bathing on the opposite shore of the lake. A little farther south from the outlet of Webster Creek is another log-loading outfit, working about 50 men. The outlet of Walsh Lake, meeting the stream which flows by Weyerhauser's Camp No. 4, forms Rock Creek, and at the junction of these two streams is situated Weyerhauser's Camp No. 2, containing, we are told, 85 men. The camp is situated 4½ miles above the city's intake, but owing to the lateness of the hour we were unable to visit this camp and obtain any data as to its sanitary condition.

POLLUTIONS AT BARNESTON.

The sawmill and camp at Barneston are situated upon an upper bench or bank, perhaps 600 to 700 feet distant from the edge of the river. The drainage of the benches at this point, if they may be said to drain at all upon the surface, is, generally speaking, away from the river, their elevation along the outer edge being higher than at a little distance back. While there is considerable pollution at Barneston and a large camp, it is probable that for the larger part it sinks into the soil and is well filtered before reaching the river. A considerable number of hogs and cattle, however, have free access to the water of Cedar River, and roam over the camp at will. Barneston is situated about 9¾ miles above the intake, measured along the line of the flowing streams.

Between Barneston and the power house the city of Seattle has constructed its pole line along the north bank of the river and

somewhat closely following the same. . For the purpose of access to this pole line, and probably originally for construction purposes, there has been built a road which follows the bank of the river, in places coming within 25 feet of the water's edge, giving full and free access to the river for the whole of its distance. Fishermen were observed trout fishing; remains of dinners were observed at the water's edge. Not far below the power house a considerable number of cattle were pasturing, which have ready access to the water of the river. A number of log jams in the river were noticed, and a great deal of decaying wood lines the stream banks, which, while common to this part of the country, is not usually considered a desirable feature of a watershed for public water supply. The sanitary conditions at the power house and the habitations there could not be criticised.

CEDAR LAKE.

The outlet of Cedar Lake was viewed. The lake appears, in many respects, to be an ideal one for purposes of water supply, the banks being for the most part steep. Near the outlet an extensive swamp borders the lake, filled with decaying wood and teeming with aquatic life. The premises of the keeper of the inlet works appeared to be properly protected, although 6 head of sheep were observed grazing about the outlet and having free access to the river. Fishermen were observed in a boat upon the lake, and the excrement of cattle upon the banks of the outlet. At one point, about 20 feet from the water's edge, human excrement was observed and noted. It is apparent that, while the conditions at this point are not serious, reliance is had fully upon the wildness and inaccessibility of the spot rather than upon any sanitary control.

The river between Barneston and the intake runs through an exceedingly wild and inaccessible region, and is very difficult of access. At only two points in this reach does the railroad line approach closely to the river, and at places it is from 900 to 1 400 feet away. No serious pollutions of any kind were observed upon this section; just above the dam of the intake there appeared to be an undesirable swamp on one side of the stream.

SUMMARY OF OBSERVATIONS.

Speaking generally, our impression was that the city of Seattle has an exceptionally good watershed, consisting of forest-covered mountain slopes and highly permeable soil, which forms, in the lower part at least, a great natural filter; mountain brooks, spring-fed and of great natural purity, freedom from permanent population, and a copious rainfall. These advantageous natural conditions, however, have not been protected, possibly, by want of adequate legal powers, but certainly by lack of suitable sanitary supervision. Many portions of the district being virtually inaccessible, much serious pollution is permitted which is probably, for the most part, unknown to the authorities.

There are about 25 miles of railroad now existing in the watershed. A considerable portion of this mileage is logging roads owned by private companies. Nearly all of these roads were traversed by us during our examination, and in no case did we see anything which seemed to us dangerous or menacing from their presence. The real menace which we observed lay in the conduct and character of the camps which were located upon flowing streams.

PROPOSED RAILROAD LOCATION.

The Chicago, Milwaukee & St. Paul Railway is proposing to enter the Cedar River watershed at or near the present power house, and traverse the valley to the intake along a line for the most part south of the river.

Ordinarily the presence of a railroad track and trains within a watershed is not looked upon by sanitary authorities as a menace when properly regulated. It is through the population and industries created by railroads that sanitary difficulties occur. Pains have been taken to investigate a considerable number of watersheds in this country which draw their waters from surface supplies, unfiltered either by artificial or natural means, and it is found that an exceedingly small proportion of cities are able to make the claim that no railroads exist upon their watersheds. Indeed, the question, so far as can be ascertained, has never before been raised as to the menace of the actual track and trains.

Following are some of the more important cities in this country which derive their supplies from surface sources, with the approximate mileage and number of stations upon their watersheds:

City.	Population in 1900.	Source.	Approximate Mileage of Railroads and Number of Stations.
New York, N. Y.	3 350 000	Croton River	45 miles railroad, 18 stations.
Boston, Mass.	560 000	Nashua River, Sudbury, and Cochituate	34 miles.
Baltimore, Md.	508 000	Gunpowder River	38 miles parallel, 41 stations on map.
San Francisco, Cal.	342 000	Lake Merced, mountain streams	None.
Providence, R. I.	175 000	Pawtuxet River	10 miles, 10 stations.
Kansas City, Mo.	163 700	Missouri River	Over 300 miles in immediate vicinity.
St. Paul, Minn.	163 000	Small lakes	No railroad.
Rochester, N. Y.	162 000	Hemlock Lake	No railroad. Summer resort around lake.
Denver, Colo.	133 850	South Platte	75 miles, 14 stations.
Worcester, Mass.	118 400	Lynde Brook	No railroad.
New Haven, Conn.	108 000	Mill River	35 miles, 10 stations.
Fall River, Mass.	104 800	Watuppa Lake	5 miles, 3 stations.
Omaha, Neb.	140 000	Missouri River	210 miles below Sioux City, 12 stations.
Scranton, Pa.	102 000	Roaring Brook, Oak River	10 miles.
Cambridge, Mass.	92 000	Stony Brook	5 miles.
Grand Rapids, Mich.	87 500	Grand River	260 miles, 70 stations.
Richmond, Va.	85 000	James River	150 miles parallel, 92 stations.
Hartford, Conn.	80 000	(Brooks)	15 miles, 4 stations.
Trenton, N. J.	75 000	Delaware River	100 miles parallel.
Waterbury, Conn.	45 800	(Ponds)	No railroad.
Mobile, Ala.	38 400	Clear Creek	No railroad.

A very large majority of cities, therefore, have railways not only upon the watershed, but paralleling the streams from which their waters are taken, nor do the majority of such cities have excessive death-rate from zymotic disease, and, so far as I am aware, no criticism has ever been seriously raised that the presence, at least of the track and trains, in such cases constitutes a menace in any way. But there are sometimes not only practical reasons why precautions should be taken to insure the purity of water supplies, there are also esthetic reasons for guarding against contamination, and particularly in a case like the Cedar River, where preliminary arrangements are possible and where proximity to the flowing stream is close, it would seem wise that some precautions should be observed which would prevent the drainage from the track from directly entering the stream, or which would prevent those passing along the tracks from access to the stream in any way.

THE OPERATION PROBLEM.

The fact that a railroad will be constructed the entire length of the river from the power house to the intake, has advantages as well as disadvantages. It provides means of approach to the river at points where it is now inaccessible, but it also provides at the same time means for controlling the watershed and observing its condition, not only by the agents of the city, but by the observation of the general public as well, which means that public sentiment will by such means be created which will result in regulations, adequate police powers, and proper control. While, therefore, to some degree a railroad so located must of necessity increase access to the river valley, its presence is an efficient check on some forms of pollution which are now in progress and which have been undiscovered.

The precautions which would suggest themselves as desirable would be, first of all, at points where the track is in close proximity to the river, to so drain the roadbed from the cuts into the soil back of the fills that, if there is any possibility of surface wash, — a possibility of which I have seen no evidences so far, — it shall be carried back upon permeable soil to diked-in sink-holes, such as naturally abound all over this area, so that such drainage shall not directly

reach the river. The drainage from the outer edge of the track may be intercepted by slightly widening the fills and forming a gutter, the waters from which can be led back to the inside of the track in the same way.

FENCE ALONG THE RIVER.

Secondly, a strong barbed-wire fence of adequate height might be constructed between the track and the river. Such a fence will, in my opinion, aid to control the situation and render it much less liable for passers along the track to defile the river in any way, or camp thereon without great difficulty.

Such a fence should be constructed by the city between the power house and Barneston along the right-of-way of its pole line, which would aid in excluding passers-by. This wagon road carries with it all of the menace of an operating railroad, and what has been said in reference to the drainage and precautions to be observed on the track of the railroad will apply with equal force to the city's own highway.

Suitable notices should be posted at frequent intervals upon such fence warning people from crossing it, just as fences with such rules are constructed around the reservoirs within the city. It is probable, of course, that malicious or ill-disposed persons will not be entirely prevented from violating the regulations of the city, but such persons have at the present time ready access to the river and stand no chance of even being discovered or controlled.

COVERS FOR BRIDGES.

The proposition of flooring the bridges with tight floors would meet with approval, and if it was thought desirable, at such points as the track necessitates, high fences could be erected to prevent the throwing of refuse from car windows directly into the river. The closets of the passenger coaches could be locked while traversing the watershed, as is ordinarily done now in traversing equal or greater distances through large cities and in all depot grounds.

These precautions should satisfy the most captious critic as to the security of the supply from the presence of the trains and track, and it might be suggested that they are much more adequate than are the provisions which are taken to guard against the contamination

of the water in the city reservoirs within the city limits from thoughtless or ill-disposed persons.

THE CONSTRUCTION PROBLEM.

No great reservoir for a water supply is ever constructed without adequate sanitary precautions. In fact, in these days no great camp of men should ever be gathered together for any public work without adequate sanitary provisions. And it is, of course, evident that construction camps along the Cedar River for twelve to fifteen months, if uncontrolled, would create a situation far from desirable. To admit, however, that adequate sanitary control cannot properly and adequately meet the situation is to admit that we know little or nothing about sanitary control. The progress of sanitary science has been such in the last generation that we have come to a positive knowledge of new dangers which threaten the life and happiness of the general community, and with this knowledge has come also the knowledge of how to properly protect and guard against such dangers. The conduct of camps, the sanitary precautions to be taken in and about them, have been thoroughly studied, with the result that where intelligent authority has been permitted to exercise full sway, all dangers have been entirely eliminated.

RULES FOR CONSTRUCTION.

The precautions that should be taken in the construction of the railroad in Cedar valley would be primarily as follows:

First, the full and complete authority of a competent and educated sanitary officer, with suitable assistance.

Second, the provision for proper location of camps safely away from the vicinity of the river.

Third, care of the camps, so far as the health of the men is concerned, and provision for the purity of their drinking water and food supplies.

Fourth, the provision for suitable conveniences for the men at or near their work.

Fifth, the removal and destruction of human excrement.

Sixth, the removal and destruction of garbage and kitchen waste.

Seventh, the care of draft animals, collection of their droppings and its destruction.

Eighth, provision for bathing purposes.

SANITARY AUTHORITY.

Absolute and autocratic authority should be vested in the sanitary officer in charge of the district to formulate such rules and regulations as seem to him necessary for the control of the camps and of the men. It would be proposed as one of the most important of these rules that all actual access to the river be barred; that the wire fences before mentioned, separating the track from the river, be constructed at the earliest possible moment; such special arrangements should be made as will obviate all necessity or desire on the part of the men to visit the stream for any purpose whatever. Such men as refuse to conform to the regulations or show themselves indifferent to their importance, or wilfully disobedient, should be promptly ejected from the camps, and a strong authority should impress upon the working force the fact that sanitation requirements are the first consideration.

All sanitary authorities agree that the best disinfectant for all forms of human waste is fire. This is the safest and easiest method to adopt in a rough country such as we are considering, where fuel is plentiful. Suitable latrines should be built at very frequent intervals along the line of work. An inexpensive crematory can be easily excavated in the bank, consisting of a rough grating immediately over a fireplace, upon which the garbage and refuse can be burned, as well as the excremental matters. Collections in large camps should be made frequently, and in the outlying and more remote latrines at least twice each twenty-four hours.

Garbage and kitchen waste of the camps should be burned along with the excremental matters. Frequent collections should be made, and no such refuse should be allowed to stand, under any circumstances, many hours. The liquid waste from the cook houses should be led in drains to some safe point where a sufficient area of subsoil can be uncovered so that filtration will be effectually permitted.

Suitable provision should be made around all of the cook houses to prevent the ingress and egress of flies which might tend to contaminate the food.

LOCATION OF CAMPS.

Camps should be placed at distances at least 500 or 600 feet from the river, on land preferably level, or draining very slightly,

if at all. Camps should be provided with a water supply, preferably from springs in the locality, or, if springs are not available, by water pumped up from the river in sufficient quantities for all purposes. It will be exceedingly desirable if the water supply of the camps can be placed under pressure, and suitable shower baths maintained for the use of the laborers, so that there is no desire as well as no opportunity or excuse for them to visit the river for any purpose. A physician should, of course, be provided, who shall watch the health of the men closely and carefully, and any case of sickness from any zymotic or intestinal disorder should be promptly removed from the watershed and all possible contamination carefully disinfected. Liberal quantities of disinfectants should be provided at every camp for the use of sanitary officers, and used under their directions.

SANITARY CONTROL OF CAMPS.

Men should be provided whose business it is to constantly keep the surroundings of the camps in a clean and presentable condition. All litter should be removed daily and burned, if possible.

Cleanliness in the bunk houses should be insisted upon. Personal cleanliness should be enforced, and persistently unclean employees should be debarred from the work.

Droppings from draft animals should be collected and burned in the same manner as human excrement. Draft animals should not be permitted to approach any stream entering the river, and always kept under full control.

IN GENERAL.

With these precautions properly taken there can be no question that all dangers of pollution to the water supply would be obviated, and that the water supply itself may be entirely above suspicion during all the time of construction. This statement is based upon the well-known efficacy of such regulations in the construction of great reservoirs, aqueducts, water supplies, even where such construction was proceeding above intakes already existing. It is also borne out by the experience of cities which purify their sewage and prevent contamination upon rivers, and it is substantiated by experience with military camps and military hygiene.

The history of the military camps has shown an increasing ability to control infection under most unfavorable conditions, and while our own volunteer army medical men did not during the Cuban War succeed so effectually as might have been hoped, they nevertheless learned a bitter lesson of the importance of such matters. Investigations of the conduct of the camps disclosed that important sanitary precautions had been entirely neglected. The typhoid which prevailed in the camps of the American army during the Cuban War is now attributed largely to the pollution effected by flies, which transferred objectionable matter from the latrines to the cook houses. And the lessons which were learned from that experience have been adopted by armies in all parts of the world so effectually that in the recent war between Japan and Russia the Japanese were practically enabled to completely annihilate this troublesome disease, as well as to reduce disease in general to the negligible minimum.

It may be remarked that the powers of a private corporation, backed by ample means and accustomed to secure efficient and capable service, unhampered by political influence or cumbersome checks, present an ideal instrument to carry out thorough and efficient sanitary control under proper supervision. So far as I can understand the situation, the interests of the railroad and the city are identical in considering this problem. Neither one nor the other can afford or should desire to trifle with matters pertaining to the public health. The attitude of both should be that of coöperation and diligence in seeking proper solution and acting on the best knowledge obtainable.

In conclusion, I believe that it is possible to construct a railroad in the Cedar River valley in a safe and sanitary manner, without a doubt. I believe, also, that once constructed, such a road, if operated without stations, with floored bridges and locked water closets, and with suitable fencing along the right-of-way, will present no opportunity for accidental contamination so great as exists at the present time. The presence of such additional men as it may bring into the watershed, due to its operation, will be, in my opinion, offset by the increased facility which it will give for patrolling the entire length of Cedar River, and for affording the authorities and the public an opportunity to observe the

conditions of its source of supply. Dangers which might occur through careless control of the sanitary conditions of the construction forces can be met with proper diligence and intelligent supervision.

It would be quite idle to ask any physician in these enlightened days if he was able to enter a home where typhoid fever existed and successfully cope with the disease in such a manner that no danger to himself or other members of the family could ensue from infection. No reputable medical man would allow for a moment his inability to fully control the situation by suitable precautions founded on long experience and careful study.

The sanitary engineer is dealing with the same problem in a broader way; he is equipped with the same sort of information, the same sort of experience, and the same results of study, which enable him with certainty to control watersheds, water supplies, construction camps, and general conditions which make for the public health. And when authority and intelligence, combined with ample backing, are provided, this successful result has invariably been fully accomplished, just as the domestic problem of typhoid has been put under control.

CONCLUSIONS.

1. That in the Cedar River watershed the city of Seattle possesses a magnificent source of water supply.

2. That the city is not now and has not in the last few years properly protected this area from gross pollutions now existent.

3. That a virgin forest or inaccessible country does not afford ideal protection from pollution, but, on the contrary, a district easily accessible in every part and open to the publicity of frequent inspections and control offers the greatest degree of protection.

4. It is the settled policy, therefore, of most sanitary control of watersheds, while preventing as far as possible the growth of population and the incidental pollution therefrom, to open watersheds freely to the public observation, by creating means of access which facilitate inspection.

5. Railroads, so far as the track and trains are concerned, when properly regulated, are not regarded as a menace to the purity of surface waters by sanitary authorities.

6. It is through population and industries created by railroads that sanitary difficulties occur.

7. The 25 miles or so of railway now existing in the Cedar River watershed are in themselves no menace to the valley, but the logging camps which they serve are so conducted as to be serious pollutions in many cases.

8. That the operation of a completed railway line by the Chicago, Milwaukee & St. Paul Railway Company on or near the present location can be made entirely safe by some simple precautions, such as fencing, drainage, closed bridge floors and locked water-closets.

9. That care should be exercised during the period of construction of the railroad to prevent all access to the water by men or animals. For this purpose the river front should be entirely fenced off, policed, and, where necessary, water should be pumped up to the camps from the river under pressure, and in suitable quantities, for all purposes, including bathing and watering animals.

10. That efficient sanitary control should be had over all camps, cleanliness enforced, refuse of all kinds promptly collected and burned, drainage filtered and commodious and convenient sanitary arrangements provided, and strict control and authority maintained.

11. That the city of Seattle should also fence in the road which it has constructed along the river bank between Barneston and the power house, so as to prevent access therefrom to the river.

12. That the city of Seattle should regulate and control by intelligent sanitary rules the various logging camps now existing upon the watershed.

13. That it would be highly desirable to prevent decaying wood and vegetable matter from defacing the shores of Cedar River and its important tributaries, and to cut off the swamps at the outlet of Cedar Lake and immediately above the intake.

All of which is respectfully submitted.

JOHN W. ALVORD,
Consulting Engineer.

JULY, 1906.

APPENDIX B.

REPORT BY PROFS. A. C. ABBOTT, M.D.; CHARLES HARRINGTON, M.D.; AND WILLIAM T. SEDGWICK, PH.D., — A COMMISSION OF SANITARY EXPERTS,—TO THE CITY OF SEATTLE, THE KING COUNTY MEDICAL SOCIETY, AND THE CHICAGO, MILWAUKEE & ST. PAUL RAILWAY, ALL OF THE STATE OF WASHINGTON, UPON THE POSSIBILITY OF THE CONSTRUCTION, MAINTENANCE, AND OPERATION OF A RAILROAD WITHIN A PORTION OF THE WATERSHED SUPPLYING DRINKING WATER TO THE CITY OF SEATTLE, WITHOUT DANGER TO ITS INHABITANTS.

We have been asked to answer two questions: *First*, whether it is possible to construct a railroad within the watershed of Cedar River, between the water intake and the power house, without danger to the character and wholesomeness of the water supply of Seattle; and, *second*, whether, in the event of such construction, the road can be operated without endangering the public health of said city through pollution of the stream.

In order to acquire personal knowledge of all the relevant conditions obtaining in and about Cedar Valley, and thus to be able to submit replies based upon something more than general principles and *a priori* reasoning, we have made a careful examination of the area involved, paying particular attention to the configuration of the ground and to the nature of the soil, and we have extended our observations so as to include that part of the watershed between the point where the proposed road leaves it to enter the Snoqualmie watershed and the borders of Cedar Lake. The proposed location of the railroad, as indicated by stakes, has been followed practically from end to end, and the adjacent strips have been examined at such points and to such an extent as seemed desirable or necessary.

We have also carefully examined and considered the various statements and arguments submitted to us.

In view of all the facts, we have no hesitation in answering both questions in the affirmative.

The main question involved in both propositions is whether pollution of the surface of the proposed right-of-way and of the vicinity by the wastes of the human body can be prevented; and, if it cannot wholly be prevented, whether contamination of the river can be guarded against.

It is a well-established fact that sewage matters containing myriads of disease germs can be rendered quite innocuous by filtration through gravel and sand, so that, within a short time, and at a distance of but a few feet, the effluent water may have an entirely different character and yield only mineral evidence of its former bad qualities. This fact was the main reason for careful scrutiny of the nature of the soil.

It appears that, along much of the proposed location, gravel and sand are not to be found. The forest floor appears to be reasonably thick, but at most points it consists almost wholly of combustible matter, and where fires have occurred the soil is shown to be chiefly loose rock, with neither sand nor gravel, and consequently not porous and suitable for effective filtration. At some points along the route, clay and silt deposits are evident, but these materials are not suitable filtering media, for they do not permit percolation. In view of these facts, special provision will be necessary for proper disposal of such waste matters as may find their way to the surface of the ground within and near the limits of the right-of-way during construction and operation of the road; for without such provisions the said wastes would inevitably be washed into the river in times of heavy rainfall, and, in the event of their containing pathogenic organisms, might lead to disastrous outbreaks of infective disease. The fact is, however, that the character of the water can be adequately safeguarded by the adoption of methods which will be described in detail further on.

The safeguarding of the water supply during the construction of the proposed road is by no means a simple matter, for construction involves the introduction of large numbers of men into the watershed, whose wastes must be prevented from reaching the river. It will be necessary to establish camps at various places, and these camps must be supplied with water, must be drained, must be

provided with bathing and laundry facilities and latrines, and in all respects must be under constant competent sanitary inspection and control far more stringent than, under ordinary conditions, is necessary. It is fortunate that a number of sites for such camps are available, at least 500 feet away from the river, on benches, where the soil, largely gravel, is dry and porous, and hence easily drained and entirely suitable for latrines. Two camps may easily be established outside the watershed; one below the intake, and one near the power house and just over the divide, within the drainage area of the Snoqualmie; and between these two points are the several sites above mentioned, on not more than two of which should camps be established.

At the several camps the necessary latrines should be board outhouses placed over reasonably deep pits for the reception of the discharges, which, out of abundant caution, should be disinfected by the application of milk of lime, made from freshly slaked lime, and kept protected from contact with the air. This should be prepared as often as twice per week, since with age it loses in causticity and germicidal power. As the pits become nearly filled, the filling should be completed with clean soil, and new ones should be dug. Between camps, other latrines should be established at intervals of a few hundred feet, and portable privies may be used, which frequently should be cleaned out and disinfected.

Rules relating to the use of these conveniences and absolutely prohibiting the discharge of human wastes elsewhere within the watershed should be enforced with great strictness and under penalty of dismissal. It will be necessary for the future needs of the section hands and others who will constantly be employed, and of the wreckers who may be brought in from time to time as one or another cause and occasion require, to establish privies at reasonable intervals; but for the last-mentioned a portable privy carried on the train, with watertight box or tank, would be preferable. Absolute prohibition of bathing and laundry work in the river must be emphasized.

In order that the stretch between the intake and the power house shall receive the minimum possible amount of human wastes, it is recommended that, while trains are in the valley, all closets be kept locked and that no stops be made except in emer-

gencies, and that no station or round house be established between those points, even with the consent of the city of Seattle by ordinance, so long as the intake of the public water supply shall be below the present power house. Therefore we recommend the amendment of paragraph 2 of Section 2 of the ordinance granting the right-of-way, by striking out the words, " without the consent of the city of Seattle first having been granted by ordinance," and, further, by making the prohibition a permanent restriction in the deed.

For the most complete safeguarding of the water it is advised that, inasmuch as the soil between the location of the line and the river is frequently impermeable, and where made up of loose stone is devoid of the qualities necessary for slow filtration, the roadbed be trenched wherever necessary or advisable, the trenches being filled with gravel and sand, and that dikes be constructed alongside the trenches wherever necessary or advisable.

The necessary bridges should have steel decks, be ballasted with gravel and sand, and be provided with means for drainage, and the water drained off should be conducted to points at least 50 feet from the river bank on each side, and discharged over appropriate areas or into gravel pits.

During construction the entire area affected should be under the unhampered supervision and control of a competent sanitary engineer appointed by the city of Seattle and approved by the state board of health. He should be empowered to employ, with the approval of the state board of health, as many inspectors to act as sanitary police as the state board may deem to be reasonable, and he and they should be given all of the powers of special police. He should be required to employ one or more registered physicians as medical inspectors, who should examine and report to the board of health of the city of Seattle upon all cases of illness, and cause the immediate removal from the watershed of all persons found to be sick of infective disease.

We recommend, therefore, the amendment of paragraphs 3 and 5 of Section 2 of the ordinance granting the right-of-way, so as to provide for these measures of sanitary protection.

After construction and during operation, so long as water shall be taken from any point below the present power house, the road-

bed should be under the constant supervision and control of a competent sanitary inspector appointed by the city of Seattle with the approval of the state board of health, and the section hands should be required to remove and properly to dispose of such obvious polluting material as may be discovered.

We feel that we should be remiss in our duty as sanitarians, although the matter is one beyond the scope of our employment, were we to neglect to call attention to the necessity of protecting the water supply of the city from possible dangerous pollution of far greater importance than any likely to be caused by the operation of a properly constructed and efficiently guarded railway.

The selection of the Cedar River watershed as a source of water supply was an eminently discriminating and wise act, inasmuch as Cedar Lake and the entire watershed are capable of yielding an abundant supply of pure, soft water. Especially commendable are the steps which have been taken to secure ownership by the city of the banks of Cedar River and Taylor Creek. But the city is apparently unaware of the fact that in using the water of an only partially protected running stream, without storage, it is exposing itself to the danger of a possible outbreak of typhoid fever or other water-borne infective disease. Contrary to common belief, founded on a mistake made by a commission who studied the subject of pollution of streams before the present methods of scientific examination were devised, the water of a rapidly moving stream does not lose its dangerous properties in a run of a few miles after it has received a specific contamination, and it is especially dangerous when this specific pollution has been discharged directly into it or has been washed into it before the action of sunlight and other agencies have destroyed the contained disease germs.

In the course of our examination, fishermen were observed here and there along the banks of the river, and in the woods near the stream were occasional evidences of occupation by camping parties. The danger of wholesale infection from the chance discharges of a single one of such trespassers is, indeed, slight; but it is a real danger, nevertheless, and when unrestricted access to the river is permitted, it becomes multiplied. We are informed that the city is taking steps looking to the abatement of local nuisances within the watershed, but we feel that it is not doing

enough, and will not do enough, until fishermen and all others who have no real business along the city's water supply, or who are not under sanitary supervision and control, are warned off and dealt with as trespassers. Better yet would be the construction of a large impounding reservoir, between Cedar Lake and the power house, as proposed by the city engineer, and the bringing down of the water in mains from that neighborhood, thus gaining the advantage of a stored water.

Respectfully submitted,

A. C. ABBOTT.
CHARLES HARRINGTON.
WILLIAM T. SEDGWICK.

AUGUST 11, 1906.

APPENDIX C.

REPORT TO THE STATE BOARD OF HEALTH OF WASHINGTON UPON THE SANITARY ASPECTS OF A GRANT OF RIGHT-OF-WAY BY THE CITY OF SEATTLE FOR A RAILROAD ALONGSIDE THE STREAM FROM WHICH THAT CITY DERIVES ITS PUBLIC WATER SUPPLY.

BY JOHN R. FREEMAN, CONSULTING ENGINEER.

1. The question is: May the city of Seattle, with due regard to the public health, grant a right-of-way to the railroad in close proximity to the river above the city's intake for a distance of 10 miles, through lands acquired by the city for the protection of its water supply; particularly in view of the facts that this river flows rapidly and that there is no detention reservoir of size large enough to detain the water a sufficient time to permit germs of typhoid to die, and no filtration works to remove them?

2. My answer is that this right-of-way may be prudently granted if proper safeguards are provided, in rigorously caring for the construction camps, in moving the railroad location somewhat farther back from the river at certain points, in carefully designing culverts, bridges, and ditches, and by providing other safeguards to be described later in detail, and all of which I believe are entirely feasible.

3. The conditions surrounding the water supply of Seattle are, in respect to detention reservoirs, materially different from those at nearly all important cities that use surface water and have railroads, highways, and villages within their watersheds and retain a low typhoid death-rate.

4. A detention reservoir, in which water from the flowing stream must be stored for a month or more before passing into the distribution pipes, is one of the greatest of all safeguards in a surface water supply, and to cite the absence of injurious effects from railroads in watersheds from which the water is stored is mis-

leading as a precedent for Seattle in the proposed location of this railroad.

5. Seattle's water supply is in many ways one of unusual excellence; it is of a very remarkable transparency and freedom from color, and therein is probably not excelled by any large water supply in America and is equaled by very few. It is, in fact, mainly water flowing from springs.

In its selection and method of first development, excellent judgment and engineering skill are shown. Its few shortcomings are mainly those incident to newness and rapid growth and are such as doubtless will be remedied as the city grows, and as fast as the engineer is given the means. I learn that the city engineer has already outlined plans for its improvement, and I doubt not that this Cedar River source can be so improved and developed as to give to more than fivefold your present population one of the finest water supplies in the world. Plainly its purity should be jealously guarded.

6. The fundamental facts on which the answers to the present main question turn are the following:

7. If a single discharge from the bowels (or from the urine) of a person in the early or "walking" stages or the convalescent stages of typhoid fever falls into, or is soon washed into, any tributary of a flowing stream so that it reaches the distribution pipes of a city within a period of two or three weeks, the thousands or millions of the germs in this one pollution may become so scattered and diffused as to enter many households, and possibly finding lodgment in the intestines of those persons whose vitality or power of resistance is low, may bring disease to a hundred and death to a score or more of citizens.

8. The second important fact is, running water does not completely purify itself from disease germs. The three safeguards opposed to the above are:

9. *First*, that the chance is very rare of perfect connection of all the necessary links in the chain of circumstances between the dropping of the pollution and its seeds of disease being sown in the human system.

10. *Second*, that nature has a wonderful process of purification in natural filtration of polluted water by the wash from such material slowly through moderate depths of sand.

11. *Third*, that after a period of two or three weeks of immersion in stream or pond, most of the disease germs die, and that for most kinds of bacteria, sunlight is a great germicide. The coolness of this spring water, its running and aëration as it flows in this turbulent stream, all tend toward safety. The precise period of detention necessary for safety, the full list of water-borne diseases (which certainly comprises typhoid, dysentery, and cholera), and the life-history of these germs, present important problems not yet fully worked out by pathologists and bacteriologists, but we may believe the main facts stated above as proved beyond all doubt or question.

12. It appears well proved, also, that some kinds of disease germs survive drying and transportation in dust, but the greatest danger to a drinking-water supply lies in the water-borne germ, less than two or three weeks old, from the bowel discharge of a human being suffering with typhoid.

Lest some timid person be unnecessarily alarmed at the possibility, by not giving due regard to the probability, I venture a comparison with Providence, R. I., an old, wealthy, and cultivated city of substantially the same size as Seattle. It has for many years taken its water directly from the flowing stream into distributing reservoirs of moderate size, presenting only three or four days' detention, and not until within the past year have its filtration works been completed. The number of inhabitants per square mile on this Providence watershed is 315, which is nearly 100 times as great as on the Cedar River watershed of Seattle; and railroad lines with frequent local trains pass along the porous, sandy margin of its river, without thought of special protection or closing of closets, for distance aggregating more than 10 miles and with 7 bridge crossings. Its last typhoid epidemic was about seventeen years ago. This was traced to a case of typhoid on the watershed, but I have not the details at hand.

On the other hand, the possibilities of the number of cases for which one or a very few sick men can sow the seed, have been shown in a remarkable way at Plymouth, Pa.; Waterville, Me.; Windsor, Vt.; New Haven, Conn.; Ithaca, N. Y.; Chelmsford, Mass.; and elsewhere.

13. These facts have come to be understood and fully proved

only during the past ten to twenty years, through the profound and patient researches of a few small groups of bacteriologists, pathologists, and engineers, and unfortunately have not all of them yet become widely diffused as matters of common knowledge.

14. This is particularly true as regards the danger that may lurk even in the transparent, attractive water of a pure mountain stream that has become accidentally polluted.

DANGERS IN WATER SUPPLIES FROM RUNNING STREAMS WITHOUT DETENTION OR FILTRATION.

15. Years ago, before the recent science of bacteriology was born, a commission of English sanitarians, working from the chemist's point of view, was led to report that a flowing river did tend to purify itself and that its impurities became oxidized.

This is to some extent doubtless true. I doubt not that the water from Cedar Lake, with its many slowly decaying trees, stumps, logs, and weeds, is improved as it tumbles over its steep course of 10 miles to the intake, and that any deleterious effect of the jams of dead logs and tree tops along the stream is thereby lessened. Bad odors from decaying organic or vegetable material are shaken out and oxidation is promoted in water running over such a course.

The half-truth of stream purification became widely circulated and to-day continues to do harm, while 10 times over it has been proved that typhoid epidemics are so carried, and that from a single case along the tributary 100 or 1 000 citizens farther down the line may suffer.

16. It has been found by later studies that water that has been held long in storage is far safer than running water as a source of domestic supply, and the large new supplies of Boston and New York, for example, are being developed with reliance upon this principle of detention for protection against the unavoidable minor pollutions.

Other cities where detention reservoirs are impracticable, for example, Philadelphia, Pittsburg, and Providence, are now constructing great filter plants. So strong is the teaching of recent science and practice concerning the economic value of this safe-

guard that I venture the prediction that Seattle will ultimately, perhaps twenty years hence, come to filtration, unless later surveys shall demonstrate the feasibility of a large detention reservoir, or shall show that sufficient water can be taken by infiltration galleries or large wells directly from the remarkable series of springs which enter the river a few miles up stream from the intake.

For there are various possible sources of pollution already existing in this watershed, such as may produce typhoid, and while some are in process of remedy, others will continue or possibly increase during the many years of lumbering, regardless of whether the St. Paul road comes in or not; indeed, the beauty and attractiveness of this region will tend more and more as time goes on to bring sportsmen, fishermen, campers, and strollers into this watershed.

THE CITY'S WATERSHED.

17. It is only five years since the city of Seattle abandoned its unsatisfactory Lake Washington source and went back about 25 miles into the forests and foothills of the Cascade Mountains and built an intake and diversion dam on the Cedar River, at about 550 feet elevation above sea level, and from this point to the city constructed a wood-stave pipe hooped with iron, 42 inches in diameter. The diversion dam raised the river but little more than 15 feet and flowed back for so short a distance and so narrow a width that the time of detention in the pond thus formed is hardly more than two or three hours, with the mean annual rate of river flow, and not more than half a day at the time of minimum flow.

The city engineer gives the following data:

The city now takes out about 23 000 000 gallons daily, equivalent to about 35 cubic feet per second.

The population supplied, including certain suburban districts, is nearly 200 000.

The present per capita consumption is thus about 115 gallons daily.

The smallest flow of the river at the intake has been found in October, and in the year 1904 amounted to 154 cubic feet per second.

This minimum flow is 4.4 times the average quantity now drawn by the city.

In years of smaller rainfall a smaller river flow may be expected, but just how small cannot be stated from the data thus far collected, which are very scant.

The total watershed area above the intake is at least 139 square miles and may possibly be 145¾ square miles.

This is made up of two areas of different characteristics, although both are heavily timbered. The upper area is more within the mountains than the lower, and comprises a little more than half of the whole, its area tributary to the proposed future high dam being 75 square miles. All of this upper watershed is more than 1 500 feet above sea level and is nearly surrounded by mountains, which increase its average rainfall above that observed in the rain gage at the lake; so that this upper half of the drainage area received more than double the depth of rain that falls on the lower half of the watershed.

The record of 1904 gave for the total annual rainfall at Cedar Lake, at an elevation of about 1 530 feet, 94.4 inches.

The total inches of rainfall during the year 1904 at the intake at an elevation of about 550 feet above the sea was 48.6 inches.

When the whole area of 145 square miles is considered, it appears that the watershed is being rather slowly logged off, so that ten or perhaps twenty years may elapse before the lumber camps will be withdrawn.

The ground in those portions not yet logged is covered with a spongelike humus of decaying vegetation, probably 6 inches deep, which absorbs and restrains the rainfall from rapid run-off, but the fires that appear inseparable from lumbering as now conducted destroy this humus and leave the ground almost bare and sterile.

Cedar Lake for the upper portion, and the vast gravel deposits for the lower portion, will, however, continue to regulate the run-off from the watershed sufficiently for the city's purpose.

The city has already purchased about one tenth of the entire watershed, this being confined mainly to lands bordering on the streams and the lake. These purchases are in some cases subject to mineral rights and the possibility of future coal mines, and in

some cases a right-of-way for future possible branch railroad lines has been reserved.

The city proposes to purchase additional areas as fast as these are logged off, and has arranged with the general government to have certain of the lands not yet sold withdrawn from sale, so that ultimately the city will own substantially its entire watershed.

It is of interest to briefly review the conditions of yield and storage for the purpose of learning if the intake at the water works could be moved up-stream.

The present temporary dam at the outlet of Cedar Lake gives at elevation 1 530 feet above sea level a storage reservoir of 1 300 acres area and 746 000 000 cubic feet capacity. A most excellent dam site that exists a mile or more farther down the stream will permit a high dam to be constructed, raising the level of the lake 60 feet, or to an elevation of 1 590 above sea, giving a storage reservoir of more than 6 times the present volume, or of 1 850 acres, and 4 835 000 000 cubic feet capacity.

This is equivalent to 36 000 000 000 gallons of storage, or half a year's supply for 2 000 000 people, without rain meanwhile.

Before one can state with certainty just how great a constant uniform draft this watershed can be made to supply, an extended study must be made of all Puget Sound rainfall records, and more observations must be had upon the rainfall and evaporation within this mountain region; and there may be remote possibilities of some escape by percolation through old channels filled with porous glacial deposits.

As a rough preliminary figure we can safely reckon that these two watersheds above the city's present intake will be sufficient for all reasonable uses of a population somewhere from 5 to 10 times as great as Seattle now possesses.

The lower half of the watershed, or that immediately up-stream from the intake, is said to be different from the upper in geological character, consisting mainly of a vast deposit of porous gravel, presumably an outwash plain from the mountains, or of glacial origin.

A comparison of the measured flow of the river near the intake with the flow at the outlet of Cedar Lake also brings out the characteristic difference of these watersheds.

While the natural yield from the upper watershed is said to fall to a minimum of about 30 cubic feet per second in August, the minimum flow at the intake dam is not reached ordinarily until October, and in 1904 was found to be 154 cubic feet per second, thus showing a yield from the lower 70 square miles at time of minimum flow more than 4 times as great as from the upper 75 square miles. Plainly the cause of this is the absorption of the winter's rains by the porous gravel deposit of the lower watershed to be stored and slowly given out by percolation to the many large springs near the bottom of the valley. These vast gravel deposits thus take the place of a storage reservoir for the lower watershed and increase its available yield.

18. It will be seen from the foregoing that to seek to avoid pollution by extending the city's intake pipe back to the power house, and thus virtually to the lake, would throw away nearly half of the available watershed area, and an area from which the water is rendered particularly transparent and pure by reason of its natural filtration. All of this watershed will be needed at some future time.

The higher dam would have to be built much earlier if the city's intake were extended farther up the stream, for the minimum yield from the upper watershed is stated to be, under present conditions, only 30 cubic feet per second, while the city to-day is using 35 cubic feet per second.

In view of the fact that the normal minimum yield at the present intake is 154 cubic feet per second, or more than 4 times as great as the present draft by the city, it will be possible to defer the expensive high dam for a number of years by continuing to draw largely from the lower watershed.

19. As the demand for power from the municipal power plant increases it will become more important to have a larger storage reservoir near the present intake than that which now exists.

The demand for power varies greatly at different hours of the day, but the delivery of the aqueduct to the city's reservoirs should be nearly constant. Wherefore an equalizing reservoir near the intake to the aqueduct will, at some future time, become necessary.

DETAILS OF PROPOSED RAILROAD LOCATION.

20. Coming now more into the details of the problem at hand, we find that the railroad, after running many trial lines, has finally staked out a line of location closely following the river for about 10 miles and twice crossing it, and also crossing the large tributary of Taylor Creek. This line runs in some places as close to the water's edge as the steep slope of the high embankment will permit, or so that the water would wash the foot of the steep slope, and riprap be required to hold it, but in general the center line will be nearly 100 feet distant from the water's edge, and for perhaps one fourth of the entire distance will be several hundred feet distant.

A view of the plan, showing the distance between the center line and the water's edge, does not tell the whole story of proximity unless one takes account of the width of roadbed and the width of the steep sloping embankment and of the somewhat nearer water line in time of flood.

21. The formation along the river near the desired location is mainly a vast glacial deposit, showing broad, deep terraces of gravel, for the up-stream 5 miles, but with apparently an increasing amount of bowlders and angular stones for the down-stream portion, so that as far as can now be seen before the ground has been cleared and burned, there will be a very scant bed of sand or fine gravel suitable for natural filtration of the wash from the roadbed along perhaps 2 miles of the line.

Within a distance of 2 or 3 miles up-stream from the intake are many flowing springs breaking out from under the terrace near the foot of the proposed railroad embankment, and the natural surface at the railroad center line is in many places moist, making it probable that when the railroad ditches are cut water will stand or flow continuously in the ditch beside the track at the foot of the inner slope.

22. It is plain from tramping along this railroad location line as now revised that an earnest effort has been made by the locating engineers to keep it farther away from the water than would be the custom under ordinary conditions, and it is plain that increased cost is already incurred in lessening the length of roadbed on

embankment sloping directly to the river, by moving the line farther back so that a considerable portion of the roadbed is in a cut.

23. But it is also plain that the line can, at somewhat further increase of cost, be pushed still further away from the river, and that in many places more of the roadbed can be made in shallow cut, so that there will be a natural earth dike between the roadbed and the river through which the natural drainage and rainwash will filter.

24. I am convinced that it is entirely reasonable for the city, as a condition of granting this right-of-way, to insist that the railroad be pushed back from the water to the very limit, and I find that the extra excavation thereby required will be mainly in gravel of loose, easy character, with some loose rock, but with little or no ledge, and the extra cost not at all exorbitant, so far as can be judged from the surface as now seen prior to clearing.

25. Many other precautions and safeguards not found in ordinary railroad construction should also be made a matter of definite agreement, competent inspection, and absolute enforcement, beyond the terms as they stand to-day in the ordinance granting the right-of-way. These will be described more in detail in the following pages.

In part it should be required that a dike of sand or gravel, say at least 3 feet high by 4 feet top width, be built and forever maintained between the roadbed and the river at all places where this is on the embankment.

Preference should everywhere be given to a roadbed in cut, so as to secure a natural dike, and, in brief, the most complete precautions should be taken regardless of expense, that any rainwash or polluting material falling on the roadbed will be safely filtered before reaching the flowing stream.

Although the chance of infection is small and remote, it is nevertheless possible and certain, and we may well remember the instance of Plymouth, Pa., for example, where it appears to have been proved that more than 1 000 cases of typhoid, with 114 deaths, resulted from the dejecta of a typhoid patient being thrown on frozen ground on the banks of a stream in a watershed that was almost uninhabited.

REASONABLENESS OF CEDAR RIVER LOCATION WITH SAFEGUARDS GUARANTEED.

First having a guaranty of the safeguards which can readily be provided and which can surely be enforced, I am led to conclude that the city of Seattle may prudently grant the desired right-of-way and that it would be unreasonable to withhold it, because of the waste in construction and operation that the best possible alternative railroad location involves, and for all of which waste the commercial interests of Seattle would ultimately have to help pay.

The risks in sanitation that will remain from the presence of the railroad after the prescribed safeguards are rigorously provided will, I believe, be of the microscopic and academic character that we continually have to accept; indeed, it can be figured out that the chance of pollution from the railroad after providing reasonable safeguards will not be one tenth as great as from other sources of possible pollution in lumber camps, sawmill settlements, strollers along the stream and in the branch railroad, all of which exist to-day and some of which will continue to exist indefinitely, and which, taken all together, are, after all, small in proportion to those that are found along the water supplies of many cities without serious epidemics.

Those fond of figures may be interested in the following computation:

Suppose 1 000 different passengers per day to pass through the Cedar River watershed on the St. Paul road; this is 365 000 per year. Health statistics of Massachusetts (the most complete in the United States) show 1.24 cases of typhoid per 1 000 inhabitants per year. Convalescents and those who have the disease in a mild form, in the first week or two of the disease, may travel. We can at most assume that 450 out of all these 365 000 passengers would have typhoid at some time during the year. Calling the duration of those stages of the disease within which one could travel a month, or one twelfth of a year, we can expect only 37 persons actually in the infectious stages will travel over the road during the year.

If these have so many as 4 stools per day, the chance is that

in the twenty minutes (or one-seventy-second of a day) occupied by ordinary trains passing through the watershed, these 37 cases would produce: Thirty-seven cases multiplied by 4 stools, divided by 72, equals 2 stools per year on track; or the probability is that only 2 discharges per year of excreta from typhoid patients are likely to be dropped on this entire 10 miles of roadbed from passengers.

When we consider that one of the residents of a lumber camp sick with typhoid may have an average of say 2 stools per day (we have figured twice this for the passengers), or say at least 50 stools during his entire illness, this is 25 times as many as we figure out as likely to come from all the passengers in a year.

With 500 persons resident in the watershed, the probability is of only .62 cases of typhoid per year among them, and, of course, most of these residents are remote from the stream.

Figuring it in another form, and assuming the domicile in as close proximity to the stream as the track: A resident population of

$$\frac{2 \times 1\,000}{50 \times 1.24} = 32$$

persons would produce the same chance of infection that will be presented by 1 000 passengers per day on the trains.

26. I am told that the best alternative railroad location outside of the watershed or not alongside the city's source of water supply will require from 5 to 7 miles greater distance and necessitate a ruling gradient 0.25 per cent. steeper eastward for nearly 20 miles, approaching the mountain division, adding that much to the distance over which helper engines must run; and that, in addition to the greater length, sharper curves, which tend to limit speed, must be used, and that much more expensive trestles and high embankments must be built, and that some adverse gradient westward would also have to be incurred.

27. With the desired line down Cedar River valley, a continuous grade of eight-tenths of 1 per cent. can be secured and the curves need nowhere be sharper than 3 degrees, permitting high-speed passenger service with outer rail elevation adapted also for low-speed freight, and the lay of the land, its slopes and stream crossing nowhere invite slides or washouts.

POSSIBLE DANGERS TO BE GUARDED AGAINST.

28. The construction of this 10 miles of railroad alongside the city's water source introduces the following specific dangers to be guarded against:

(*a*) For about a year's duration construction gangs aggregating about 500 men will be employed along this 10 miles of river, thereby not only doubling the present total population, but placing all of these new men very near to the main stream. There will also be many camp followers and tramps.

(*b*) At the foot of the steeper eastward grade, near the city's power house, a station for helper locomotives will be established, with a round house and a few residences, which will increase as the business of the railroad grows. It is feasible to locate all of these buildings so that although located within 200 feet of the river their drainage can pass down an ancient channel into another stream, because of the very peculiar lay of the land at this point. But the bringing of this additional population brings more persons who will fish, hunt, or stroll along the nearby stream and who may chance to some time thoughtlessly pollute it.

(*c*) After the road reaches the operating stage, the passenger trains and freight trains will continually carry more and more, and with human nature as it is there will always be the chance of dangerous pollution dropped on the roadbed by those in the early stage of typhoid, dysentery, or other disease, in spite of the rules to lock the toilet rooms during the one-third or one-half hour occupied by a train in passing.

Freight trains and sometimes passenger trains will be detained on the long siding midway.

(*d*) From 6 to 10 section men will be continually engaged in maintenance work on this 10 or 11 miles of track close to the river.

(*e*) By opening up the country and making it more accessible to fishermen and sportsmen and picnickers, a railroad will be the means of bringing more people along the banks of the stream.

(*f*) Tramps, careless and reckless of regulations, will probably, in course of time, follow the railroad line.

(*g*) Double tracking or new bridges, wrecks or other work bringing in large gangs of workmen, are all likely to come in course of time.

29. The safeguards against the possible danger of pollution from the causes just described are all matters of simple care and common sense, all centering around the idea of keeping people out of the watershed or away from the tributary streams so far as possible, and of so placing camps, latrines, sidings, and main roadbed that the rain-wash from any defections or other pollutions will filter through a safe thickness of sand or fine gravel before it reaches the stream, and that all these localities shall be so far removed from the water or so shielded as to practically remove the chance of dust containing any of these germs from being blown into the water.

SANITARY OVERSIGHT REQUIRED.

30. The detailed specifications for much of this work cannot be properly made until the 100-foot right-of-way has been opened up and enough of the cut made to disclose the character of the ground for filtration, and whether flowing springs develop in the hillside districts; therefore the oversight of the whole matter should be placed with some competent sanitary engineer, working under authority of the city of Seattle and the state board of health, who should, from time to time, go over the line as construction progresses, in consultation with the chief engineer of the railroad, to frame such detailed specification as may be demanded by the character of the ground.

The supervising sanitary engineer should have his deputy continually on the ground during the progress of the work in the person of the chief sanitary inspector.

During the year of active construction this chief sanitary inspector will require the services of 3 or 4 deputies to look after the details of sanitation properly. At least one of these should be a physician skilled in the detection of typhoid and who should keep close watch of the health at the several camps. The entire line where work is going on should be patrolled twice daily.

After the construction period is over an inspection should be made at least once a month over the entire length of the railroad line of the St. Paul and also over the present Northern Pacific branch railroad. The sawmill village and the several lumber camps and the shores of the main stream all the way above the

intake should also be inspected once a month by some one trained in sanitary science, and a record made on a carefully prepared blank, giving the conditions found, should be placed on file with the city water department.

31. Three or possibly 4 construction camps will be needed during the building of this 10 or 11 miles. Two of these camps can be located outside of the watershed, one at either end.

There are admirable locations for the 1 or 2 intermediate camps at points where the roadbed is located upon a bench several hundred feet back from the river.

32. Each of these 1 or 2 camps within the watershed should have its water supply piped in for drinking, cooking, and washing, and with hot water also on tap. This camp supply in general should be made more convenient than to visit the river for water. Deep pits should be dug into which all drainage from washing and cooking should be led to slowly filter away. Numerous light wooden privies that can be readily moved should be built and placed over pits, and these should be regularly disinfected by lime and slowly refilled with earth. A barbed wire fence of double strength should separate the camp from the river. Before occupancy the camp ground should be cleared of all trees and underbrush and the space between the camp and the river should also be cleared and burned for half a mile each way along the line so as to remove all cover.

Then with a sufficient number of sanitary inspectors and the prompt discharge of offenders, it will be entirely feasible to make the camp safe, as has been done on recent large work for the city of Boston close beside its water sources, where many foreign laborers were employed.

It should be made a part of the contract between the city and the railroad that any laborer, foreman, or other employee caught transgressing the sanitary rules will be immediately dismissed; and if one or more of the sanitary inspectors be given authority of a constable to arrest any offender against the health ordinance, it will help.

LOCATION OF RAILROAD FARTHER BACK FROM RIVER.

33. A relocation of the railroad line farther back from the river is the first work demanding attention.

To do this important work in the best manner and as a basis for laying out the further safeguards, a new survey map should be made on the scale of 100 feet to the inch, utilizing all present topographic notes and immediately putting surveyors in the field to extend the contours to cover with greater precision all of the ground between the road and the river and to reach up to the top of the terrace.

ENLARGED DETENTION RESERVOIR AT INTAKE.

34. The railroad grade may need to be placed at an elevation perhaps 20 feet higher (more or less) than it has yet been located, where it crosses the intake pond of the city water works, in order that the city may not sacrifice its opportunity to construct more of a detention and equalizing reservoir at the intake. Reference has already been made to its importance at some future time, for equalizing the irregular draft of water for power, so that it may be taken into the water supply conduit at a uniform rate, and whatever can be gained in detention of the water from the rapidly flowing stream before it enters the city's supply will be an advantage.

Surveys and studies on behalf of the city are needed to find out just how far such an enlargement of the present intake pond is feasible. The railroad's line as now surveyed is understood to permit little or no enlargement, and its engineers will naturally be opposed to raising the grade at this point.

Apparently no very good opportunity exists for a sufficient detention at the intake, this being complicated by the fact that the flood flow is many times larger than the city's present rate of draft; but this condition will change somewhat as the city grows and the Cedar Lake storage capacity is largely increased, and the matter is well worth the cost of immediate surveys and studies before the railroad makes the larger reservoir at this point forever impracticable.

CLEARING GROUND BETWEEN THE RAILROAD AND THE RIVER.

35. The trees should be cut, the logs removed, the stumps and dead wood burned, for the entire 100-foot width of right-of-way of the railroad. The ground between the railroad and the river

should all be similarly cleared and kept cleared, the object being to remove all cover and to permit easy inspection from the railroad and the prompt discovery of any trespassers.

The city, for its part, might also completely clear a strip 100 to 200 feet wide on the opposite bank, also for the purpose of removing cover and for making its sanitary patrol easy and efficient.

The value of shade for keeping the water more cool is mainly fanciful and far less than the value of the sun as a germicide. Ease of inspection is one of the greatest of all safeguards.

FENCING.

36. A barbed-wire fence should also be built along the inner boundary of the railroad's land as soon as the work of felling trees, burning and clearing is completed. This fence should be extra strong and tight, its object being to impede access to the water of tramps, railroad section men, or those who may leave the trains in case of accidents or detentions at sidings.

Should it be concluded that it is too much to ask for the maintenance of such a fence over all of this 10 or 11 miles, it should certainly be insisted upon for a strip nearly a mile in length near each construction camp and near the permanent siding.

CULVERTS.

37. Culverts, preferably of cast-iron pipe, of ample size, with tight joints, should be laid safely below frost, and for the entire 100-foot width of the right-of-way, for all small streams, flowing springs, and gulleys that give evidence of stream flow in time of rain.

An effort should everywhere be made to protect these small natural streams that cross under the roadway from any possible rain-wash of polluting material dropped on the railroad right-of-way by passenger, tramp, trainhand, or workman.

SIDE DITCHES AND DRAINS.

38. Where the railroad cut lies through moist ground, so that water percolates into the ditch on the uphill side, forming at times a running stream along the ditch, the ditch should be deepened

about 3 feet or more, according to circumstances, and have a width of at least 2 feet. In the bottom of this trench vitrified drain pipe, not less than 6 inches in diameter, and generally more, according to extent and length of water found, should be laid with open joints, surrounded and covered with coarse gravel for at least 1 foot in depth, and over this filled with fine gravel up to the ordinary form of a railroad side ditch. This drain pipe should be extended a sufficient distance through dry, porous gravel to permit the water thus collected to filter away through a safe distance of not too coarse earth before reaching the river.

39. There are several localities within this 10 miles where, so far as can to-day be seen, the ground will be found so rocky after the humus is burned off that it will perhaps prove unsuitable for filtering material. This is particularly true at several points within 2 or 3 miles of the intake. At such points the rain-wash from pollution dropped on the road ballast might fail of proper detention and purification unless ditches and drains are constructed as described in the preceding paragraph. It may, after further investigation, be found best to carry large drains of the type just described down stream from localities near the intake so that they will discharge below the watershed limits. The fact that the grade of the railroad descends without interruption at the rate of about 40 feet per mile for the entire distance of 10 miles makes drains of this kind feasible.

The details of side-ditches and vitrified pipe drains and the gravel covering them will have to be studied out on the ground after its character has been more fully shown up by clearing off the timber and dead wood, burning off the humus, and making the main cut.

SIDING.

40. Only one side track for passing trains is desired within this 10 miles. An excellent site for this is found on a high bench or terrace of gravel nearly opposite the sawmill village of Barneston. At the site of this siding the railroad line should be crowded against the hill so as to give greatest possible distance from the river. By so doing a distance will intervene that can be regarded as entirely safe.

To provide against possible pollution during the long detention of freight trains here, 3 or 4 small, neat privies should be constructed along the line over pits dug deep in gravel, and the whole properly cared for as part of the regular maintenance work of the section gang.

Here and at all tool houses for the section gangs it may not be amiss to pipe from the small spring on the hillside so as to give a convenient drinking-water place, and to lead the drainage therefrom into a blind drain in the porous gravel.

A location about a mile below Barneston also furnishes a favorable site for one of the construction camps and for a tool house and headquarters for the section gang.

The ordinance should forbid any regular station on the railroad within the watershed.

SECTION GANGS.

41. After the railroad construction is finished and the road is in operation, its maintenance will require the continual services of, say, 1½ section gangs for this 10 miles.

It can doubtless be arranged that only 1 gang will have its headquarters and its tool house within the watershed limits, while the ends are cared for by the gangs domiciled just outside.

Conspicuous notices, in large type, should be placed in all the section tool houses for each of the 3 gangs that work within this watershed, directing attention to the preservation of the purity of the city's water supply. Small, neat privies over deep pits should be maintained, at convenient intervals, for the section gangs along the entire 10 miles of road within the watershed, to the satisfaction of the city's sanitary inspector, and the section men should be instructed to bury, immediately, any polluting material found on the track.

BRIDGES.

42. It is already prescribed in the ordinance that the bridges are to be tight deck bridges. The St. Paul road crosses the main river twice within the watershed and makes an equally important crossing of Taylor Creek, which is also a large, rapidly flowing stream.

It would be almost impracticable to secure by ordinary methods of railroad bridge construction a deck so tight that heavy rain would not wash pollution through it or around the end of its parapet back into the stream.

Special care, therefore, must be given. My recommendation is for a reinforced concrete arch bridge at each of these 3 important crossings, having the top of its arch, say, at least 2 feet below the bottom of the ballast and with a space over the arch filled with moderately coarse porous sand, such as will afford good filtration. The side parapets should be carried up 4 feet above the rail and extended for at least 50 feet into the bank beyond the high water line.

The smaller creeks and the channels that run strong in time of heavy rains should each be the subject of a somewhat similar precaution.

HELPER-ENGINE STATION.

43. Near to the city's electric power station, but just outside the city's watershed, there will be located a small round house for locomotives used to help trains up the heavier eastward grade that begins near this point. The lay of the land here is so peculiar that, although distant but a few hundred feet from Cedar River, all of these buildings can be made to drain outside the watershed, and the only danger is that as business grows and the station becomes larger, men off duty, or members of their families, will stroll along the river and might thoughtlessly pollute it. It will doubtless be sufficient for the city to require the maintenance of an extra strong and tight barbed wire fence along the railroad location here, and to post conspicuous notices asking for thoughtful care in preserving the purity of the water.

ANTI-POLLUTION NOTICES.

44. It will be useful for the city to prepare a large number of conspicuous notices, printed on cloth in very coarse type, briefly asking the coöperation of all who walk along these portions of the river to lend their aid in preserving the purity of the city's drinking water supply, and to nail these to posts and trees all along the line of Cedar River, and also along those creeks and valleys that pass near to the lumber camps.

Such a request for friendly aid will doubtless be as efficient as posting copies of the health ordinances with a description of the penalties.

LOCKING OF PRIVY DOORS ON CARS.

45. Representatives of the railroad have offered the suggestion that the closet doors could be locked during the times that trains are passing over this 10 or 11 miles of track within the city's watershed, and, perhaps relying on this safeguard as sufficient, had not proposed such extensive structural precautions as I have outlined above.

It appears certain to me, after careful consideration of the known facts regarding typhoid and of the epidemics that have been plainly traced to pollution of a flowing stream, that the safety of the citizens of Seattle demands the more certain, although much more expensive, safeguards herein recommended.

The time of crossing the watershed by a passenger train on an up-grade might often be nearly half an hour, and for a freight train the period would be longer, and still longer periods within the watershed are probable in case of detention at the siding waiting for a belated train, or while waiting for a clear track after a wreck.

Persons coming down sick or homeward bound with typhoid or dysentery, or in the early and unrecognized, but infectious, stages may be among the passengers, and it is too much to expect or to require that the door would always be kept locked against urgent need.

Detachable pans under the car closet may possibly, at some future time, come into use, as is now being done on some German railroads, but it is too much to expect that their use could be relied on on all sorts of cars on this 10-mile run between unimportant stations out in the woods. The only safe way is to safeguard the roadbed construction on the theory that closets will often be left unlocked, and then add to the safety by keeping them closed as much as can properly be done.

REMEDY OF EXISTING POSSIBLE SOURCES OF POLLUTION.

46. My own examination was confined to the proposed St. Paul railroad line and the territory adjacent thereto.

Whatever chances of pollution may exist to-day, these are plainly no justification for an increase in the chance of pollution, and therefore I did not consider that the present question required me to seek out the various settlements in the watershed or to inspect the lumber camps, but at Barneston our party spent the night, and thus had opportunity to note existing conditions.

I am told that there are now about 500 persons resident within this watershed. This is a remarkably small number per square mile as city watersheds go, and would not give rise to serious apprehension except for the fact that the city takes its water directly from the rapidly flowing stream and that a part of this population, at least, resides in undesirable proximity to rapidly flowing tributaries.

At Barneston the village of the Japanese sawmill laborers, in time of heavy rains, now drains directly into Cedar River, but I am told that new houses for these laborers are already approaching completion and that present houses and privies will soon be torn down. So in the lumber camps and elsewhere doubtless improvement will be the order of the future, and the chief sanitary inspector that the city employs on this railroad work may, during the year of railroad building, very properly extend the scope of his inquiry and study of improved conditions throughout the watershed.

INVESTIGATIONS FOR IMPROVEMENT OF SUPPLY.

47. With the best sanitary inspection that is practicable a rapidly flowing stream will always present some remote chance of danger, and therefore I am led to earnestly recommend that the city engineer make, in the immediate future, a sufficient reconnaissance both for the enlarged detention reservoir at the intake already mentioned and also for learning just what opportunity there may be of securing a supply sufficient for the present needs of the city from the remarkable series of large cool springs within 2 or 3 miles of the present intake. An inspection of the map of the watershed boundaries gives small hope that these springs will suffice for anything more than a temporary supply, but the present is a good time for reviewing all of these possibilities and for making full and precise measurements that will be very useful in all future studies.

FISHING.

So long as no detention reservoir exists and the water is without filtration, fishing along Cedar River above the city's intake may well be prohibited, not on account of the fishing, but simply as one more means of lessening the chance of a man in the early and unrecognized stages of typhoid strolling along this stream. Even the spit of one coming down with typhoid is said to contain the germs of the disease, and the typhoid bacillus sometimes continues to be found in the urine for several weeks after the patient is so far convalescent as to be walking around.

SWAN LAKE AS A DETENTION RESERVOIR.

A part of the chief engineer's original plans was to provide a period of detention of the Cedar River water in Swan Lake. This lake is reported to have been found containing large quantities of wild fowl guano at its upper end, and it is also stated that the elevation above sea level is somewhat smaller than desirable for economy in size of aqueduct to the higher levels of the city.

In view of the well-known possibilities of danger in taking water from a flowing stream, I venture to suggest that this whole matter of Swan Lake and other possible sites for a detention reservoir should be carefully studied anew.

The expense already incurred by the city in securing a sparsely settled mountain watershed, and in systematically beginning to purchase the fee to the entire area as a means of excluding pollution, the excellence of this gathering ground, its sufficiency for the city for many years in the future, the great importance of a supply of water pure beyond suspicion as an asset in encouraging the city's growth, all concur to make this question of avoiding any new source of pollution paramount.

The one death per thousand inhabitants per year from water-borne typhoid may as easily be the foremost citizen as the humblest.

Respectfully submitted,

JOHN R. FREEMAN,
Consulting Hydraulic Engineer.

AUGUST, 1906.

PROCEEDINGS.

NOVEMBER MEETING.

HOTEL BRUNSWICK,
BOSTON, November 14, 1906.

President William T. Sedgwick in the chair.

Before the members took seats, a toast was drunk in silence to the memory of Freeman Clarke Coffin, whose funeral fell on the day of the meeting.

The following members and guests were in attendance:

MEMBERS.

S. A. Agnew, C. H. Baldwin, L. M. Bancroft, J. E. Beals, F. D. Berry, J. M. Birmingham, J. W. Blackmer, E. C. Brooks, G. A. P. Bucknam, George Cassell, C. E. Childs, J. C. Chase, R. C. P. Coggeshall, M. F. Collins, W. R. Conard, M. J. Doyle, C. R. Felton, Desmond FitzGerald, A. N. French, F. L. Fuller, J. C. Gilbert, A. S. Glover, J. O. Hall, L. M. Hastings, V. C. Hastings, T. G. Hazard, Jr., D. A. Heffernan, H. G. Holden, J. L. Howard, Willard Kent, G. A. Kimball, G. A. King, Morris Knowles, E. E. Lochridge, Thomas McKenzie, Hugh McLean, H. V. Macksey, D. E. Makepeace, A. E. Martin, W. E. Maybury, John Mayo, F. E. Merrill, H. A. Miller, Wm. Naylor, F. L. Northrop, J. H. Perkins, W. W. Robertson, E. M. Shedd, G. A. Stacy, J. A. Tilden, A. Townsend, R. J. Thomas, H. L. Thomas, W. H. Thomas, J. L. Tighe, D. N. Tower, W. H. Vaughn, C. K. Walker, J. C. Whitney, F. E. Winsor, G. E. Winslow. — 61.

HONORARY MEMBERS.

W. T. Sedgwick, F. W. Shepperd. — 2.

ASSOCIATES.

Ashton Valve Company, by C. W. Houghton; Harold L. Bond & Co., by Harold L. Bond; Hersey Manufacturing Company, by Albert S. Glover, J. A. Tilden, F. A. Smith, W. A. Hersey, H. V. Macksey; International Steam Pump Company, by Sam'l Harrison; Ludlow Valve Manufacturing Company, by H. F. Gould; H. Mueller Manufacturing Company, by O. B. Mueller and Geo. A. Caldwell; National Meter Company, by Chas. H. Baldwin and J. G. Lufkin; Neptune Meter Company, by H. H. Kinsey; Perrin, Seamans & Co., by Chas. E. Godfrey; Rensselaer Manufacturing Company, by Fred S. Bates and C. L. Brown; A. P. Smith Manufacturing Company, by F. N. Whitcomb; Platt Iron Works Company, by F. H. Hayes; Thomson Meter Company, by S. D. Higley and E. M. Shedd; Union Water Meter Company, by Edw. F. King and F. L. Northrop; United States Cast Iron Pipe

and Foundry Company, by F. W. Nevins; R. D. Wood & Co., by Wm. F. Woodburn; Water Works Equipment Company, by W. H. Van Winkle. —26.

GUESTS.

George H. Finneran, Thomas A. Lennon, Boston, Mass.; E. L. Harvell and John H. Burke, water commissioners, Rockland, Mass.; A. W. Danforth, Reading, Mass.; Dr. Benj. P. Wall, Berkeley, Cal.; Arthur E. Blackmer, superintendent, Plymouth, Mass.; Wm E. Bailey, commissioner, Beverly Mass.; H. O. Brooks, Lowell, Mass. — 9.

[Names counted twice — 6.]

After luncheon had been served, and before the opening of the regular exercises of the afternoon, an informal address of thanks was made by the President, on behalf of a large number of active and associate members of the Association, accompanied by the presentation of a gold watch, duly inscribed, to Mr. Frank E. Merrill, whose services in connection with the annual convention at Fabyans, N. H., were not only untiring and self-sacrificing, but highly appreciated. Mr. Merrill, to whom the presentation came as a complete surprise, made a response accepting the gift with hearty thanks and expressions of satisfaction in the kind feelings which prompted it.

Applications for active membership by the following-named persons, properly endorsed and recommended by the Executive Committee, were presented by the Secretary:

William C. Lounsbury, Superior, Wis., bacteriologist and chemist for the Superior Water Company; Henry A. Symonds, Athol, Mass., superintendent water works; George H. Finneran, Boston, Mass., chief clerk distribution division, Boston Water Department; Andrew S. Corr, Phillipsburg, N. J., inspector of cast-iron pipe for gas and water companies, and water-works materials for various cities and corporations; Hardolph Wasteneys, Brisbane, Australia, chemist to the Brisbane Water Works and director of laboratory; C. P. Nibecker, Pittsburg, Pa., connected with the operation of filter plants for the American Water Works and Guarantee Company; Edgar A. Cate, Everett, Mass., in charge of water income and department accounts; Elton D. Walker, State College, Pa., professor of hydraulic and sanitary engineering, and expert for Pennsylvania State Department of Health.

On motion of Mr. Coggeshall, the Secretary was instructed to cast one ballot in favor of the applicants, and he having so done they were declared regularly elected members of the Association.

The President read the following minute adopted by the Executive Committee and ordered to be presented to the Association for its action:

" It has come to the knowledge of your Executive Committee that the appropriation for the gaging of streams and other investigations of the water resources of the United States by the United States Geological Survey was reduced at the last session of Congress by the large amount of $50 000, this being one fourth of the whole sum previously appropriated. We learn also that some of the congressmen from New England were active in bringing about this reduction. We therefore recommend that the following minute be adopted by the Association and spread upon its records, and that a copy of the same, signed on behalf of the Association by the President and Secretary, be mailed to every member of Congress from New England.

" ' The New England Water Works Association has learned with regret that a reduction of $50 000 was made at the last session of Congress in the appropriation in the Sundry Civil Bill for the work of the United States Geological Survey in the gaging of streams and other investigations of the water resources of the United States. The Association believes that this reduction was uncalled for and has already done harm. It desires to place on record its appreciation of the hydrographic work of the United States Geological Survey, and its earnest hope that the members of Congress from New England will exert themselves to see to it that the reduction be not continued beyond the present year. It believes that the industrial progress and the sanitary welfare of the people of New England largely depend upon the conservation and development of their water supplies, and it commends the judicious activity of the United States Geological Survey in making stream measurements, investigating the pollution of interstate rivers, and, in general, in seeking out and making known the water resources, not only of New England, but of the whole country.' "

Mr. Frank L. Fuller moved that the minute as read be accepted and adopted. Carried.

Mr. Robert J. Thomas called attention to the vacancy in the list of nominees for officers for the ensuing year presented by the Nominating Committee, caused by the death of Mr. Freeman C. Coffin, who was named for one of the vice-presidents, and moved that the same committee be authorized and instructed

to make a new nomination to fill the vacancy. The President stated that the constitution does not make definite provision for a contingency of this sort, but if the motion were passed without objection it ought to have all the force of law and the constitution. Adopted.

The President again expressed his great desire that at the meetings of the Association a larger number of practical experience papers should be presented than has been customary in recent years. Speaking upon this subject, he said:

"As many of you know, I have been anxious that we should have at our meetings a greater number of practical papers by the water-works superintendents of New England. We find it easy enough to get learned, scientific papers, and we want these. It has been the glory of this Association that it has had so many such papers, and that some of the most important original articles of the day in water-works science have been read at our meetings and published in our JOURNAL; but for a large majority of our members actual experience papers would be of no less, and perhaps even greater, interest. Your officers, however, have no way of arranging for such papers unless these are volunteered by communications from individual members. If any man is having trouble with any particular problem, and is willing to talk frankly about it, and get advice from his fellow superintendents, let him drop a note to Mr. Kent and say he would like to talk for five minutes or more on such or such a subject. We shall welcome suggestions of that kind, and I am particularly anxious that the coming meetings, if we can arrange them so, shall be devoted largely to such discussions. To-day we have the more scientific and more learned papers, so-called, but we ought to have at about every other meeting practical papers also, dealing with the difficulties that practical men are encountering from day to day. If there is a judicious mixture of the two kinds of papers, the Association will go on to even greater successes than it has attained hitherto, while if it gives itself up wholly to either alone it will surely fail of accomplishing the best results. So we beg any one of you who has in mind any topic he thinks it would be interesting to have discussed, to write to Mr. Kent or to me or to any member of the Executive

Committee, and we will try to arrange for its discussion and see that it goes off well."

The first paper of the afternoon was by Mr. Charles R. Felton, city engineer, Brockton, Mass., and was a "Description of Brockton's New Water Works," illustrated by stereopticon views. Remarks were made in connection with the paper by Mr. Desmond FitzGerald and Mr. Morris Knowles. The second paper was by Mr. L. M. Hastings, city engineer, Cambridge, Mass., entitled "A Study of Some Vital Statistics." This, also, was illustrated, and the discussion was participated in by President Sedgwick, Mr. Desmond FitzGerald, Mr. Morris Knowles, Mr. Frank L. Fuller, Mr. Hiram A. Miller, Mr. Robert J. Thomas, and Mr. Charles R. Felton.

Adjourned.

EXECUTIVE COMMITTEE.

Tremont Temple, 11.30 A.M., November 14, 1906.

Present: President William T. Sedgwick, and John C. Chase, Robert J. Thomas, James L. Tighe, George A. Stacy, Lewis M. Bancroft, Frank E. Merrill, and Willard Kent.

Eight applications were received and the applicants recommended for membership.

Eulogistic remarks were made on the life and character of our late associate, Mr. Freeman C. Coffin, and the committee on nominations of officers of the Association for the coming year were requested to fill the vacancy in the list already issued caused by his death.

The question of place of next annual convention was discussed, and on motion of Mr. Chase, seconded by Mr. Tighe, the subject was referred to the next meeting of the Executive Committee.

On motion of Mr. Stacy, seconded by Mr. Tighe, it was voted:

That the Executive Committee recommend to the Association that the Association express its regret at the action of Congress in reducing the appropriation for the measurement of streams, etc., by the United States Geological Survey.*

Adjourned.

WILLARD KENT, *Secretary.*

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*See minute as printed on page 489.

OBITUARY.

WILLIAM WINSLOW BURNHAM died in the Wilmington, N. C., hospital, August 11, 1906, of typhoid fever, after an illness of seven weeks.

Mr. Burnham was born in Biddeford, Me., August 24, 1875, graduating from the Biddeford High School in 1892, and from the sanitary engineering course of the Massachusetts Institute of Technology in 1903. Immediately after graduation he obtained a position in the engineering office of the Massachusetts State Board of Health, which position he resigned June 1, 1904, when he accepted an appointment to the United States Geological Survey, Hydrographic Division. While in this position his work involved the determination of the depth of ground waters over the desert region known as Carson Sink. He was also connected with the Truckee-Carson irrigation project which the government is now constructing in Nevada. In the fall of 1904 he made a survey of the surface and artesian waters of Georgia, which completed his work with the United States Geological Survey.

February 1, 1905, he became the engineer of the Hugh MacRae Company of Wilmington, N. C., with which company he remained until his death.

Mr. Burnham was married, March 6, 1906, to Miss Ella M. Cate, of Malden, Mass.

He was a member of the Boston Society of Civil Engineers. He was elected a member of this Association on September 13, 1905.

FREEMAN CLARKE COFFIN, civil engineer, died at his home in West Medford, Mass., on November 11, 1906, after a brief illness.

Mr. Coffin was born in Boston, September 14, 1856, but while he was very young his parents moved to Patten, Me., where he received his early education, and later started in the manufacture of furniture. In 1882 he came to Boston and entered the employment of the Coffin Valve Company, of which his uncle was one of the managers, as a pattern maker, but seeing no opportunity to rise in this work looked for engineering employment, and after two years entered the office of the late M. M. Tidd. Mr. Tidd was at that time probably better known as a water-works designer and builder than any other engineer in New England.

Up to this time Mr. Coffin had had no training or experience in engineering work, and he was then twenty-eight years of age. Nevertheless, in about two years he became Mr. Tidd's principal assistant. He remained with Mr. Tidd about ten years, and in 1894 started in business for himself, making a specialty of water works and sewerage systems. During the twelve years he was in business he constructed many such systems in the United States and Canada, and also acted as expert in a number of water-works valuation cases.

A few years ago he published a valuable handbook entitled "Graphical Solution of Hydraulic Problems."

The high position attained by Mr. Coffin in his profession is too well known by the members of this Association to need amplification here. At the time of his death he was the senior vice-president of the Boston Society of Civil Engineers, and chairman of the Sanitary Section of that society. He was also a member of the American Society of Civil Engineers, and of the Canadian Society of Civil Engineers.

Mr. Coffin had much to do with inaugurating and carrying out a great deal of the most important technical work done by this Association. A brief paper entitled "A Few Notes on Cast-Iron Pipe," presented by him in March, 1900, published in the JOURNAL for September of that year, suggested the preparation by this Association of standard specifications for cast-iron pipe;

as a result a committee was appointed, with Mr. Coffin as chairman, which, after a great deal of work, gave us our present admirable standard specifications. Later, as the result of a brief paper presented by him in January, 1904, a committee on meter rates was appointed, with Mr. Coffin as chairman. For the committee he opened a topical discussion on this subject at the March, 1904, meeting, and submitted progress reports at the 1905 and 1906 conventions. This committee is still in existence.

Mr. Coffin had also presented to the Association a considerable number of papers. Among the most important of them may be mentioned the following:

"Standpipes and Their Design," 1893; "Financial Management of Water Works," 1896; "Friction in Several Pumping Mains," 1896; "Application of Gas, Gasoline, and Oil Engines to Pumping Machinery," 1899; "Covered Reservoirs and their Design," 1900.

He had never held office in this Association, but had just been nominated for one of the vice-presidents for the year 1907. He was elected a member on February 13, 1899.

BOOK REVIEW.

QUASI-PUBLIC CORPORATION ACCOUNTING AND MANAGEMENT. By John F. J. Mulhall, P.A. Boston: Corporation Publishing Company. Half morocco, 6¼ x 9½ inches. Pp. 203. Price, $5.00.

This book treats principally of the accounts and other records which should be kept by public-service corporations, including water, gas, electric light, steam heating, telephone, and electric railway companies. Two brief chapters are devoted to the formation of corporations and information relating to stocks and bonds, with examples of stock certificates, bonds, coupons, trust deeds, etc. The remainder of the book is devoted to the forms of accounts, records, etc., needed in the operation of such a corporation.

Water works are first taken up, and are treated at greater length than any of the other kinds of public-service works. This is, however, because many of the forms required are substantially the same for all such systems, and the principles having been once set forth under the head of water works, it would be mere repetition to present them again in detail under each of the other kinds of works.

Copies of all the important forms are given, in most cases illustrated by cuts showing actual forms on reduced scale. Methods of keeping the customers' accounts, as well as the ordinary accounts of the company, are explained. A part of this section of the book was outlined by the author in a paper presented to this Association at its convention in 1905, and is printed in the JOURNAL for December, 1905, page 395.

Quite as important, in many ways, as the financial record of such a company, are the "house-to-house inspection," "on-and-off" and meter records, construction records, etc., which are illustrated in some detail.

The special accounts and records required by the other kinds of public-service works are explained and illustrated in the section devoted to those works. A commendable feature is the inclusion of the form of report required by the Massachusetts Board of Gas and Electric Light Commissioners.

The difficult but very important subject of depreciation is discussed briefly. Tables of annuities, compound interest, and sinking funds are also given.